Analysis of Activate Good Weekly Newsletters, 2019-2020

STATCOM

Abstract

There are four main sections in this final report: 1) Exploration of Aggregated Metrics, 2) Trends in the Open Probability, 3) Trends in the Click Probability, and 4) Link Characteristics that Promote Clicks. Each main section is headed by an executive summary that describes i) the questions of interest that the main section aims to answer, ii) the statistical methods used to answer the questions, and iii) what we believe are the most pertinent takeaways of the main section.

Contents

1 Exploration of Aggregated Metrics: Executive Summary

1.1 Questions of Interest

- What are some general trends regarding the weekly newsletters' aggregated metrics (open, click, bounce and unsubscribe rates)?

1.2 Statistical Analysis

- Correlations between the metrics
- Scatterplots of the metrics vs. various factors

1.3 Takeaways

- Clicks are positively correlated with opens, but negatively correlated with unsubscribes.
- The start of the COVID pandemic seemed to have caused a temporary spike in engagement.
- The next two reports, "Trends in the Open Probability" and "Trends in the Click Probability," will delve further into how various factors affect the open and click rate.

2 Exploration of Aggregated Metrics: Report

2.1 Overview of the Data Used

We focus on 54 newsletters, sent roughly weekly in the years 2019 and 2020. For this initial report, we look at four aggregated metrics for the newsletters: the open, click, bounce, and unsubscribe percentages.

The definition of the metrics are as follows:

$$\text{Open } \% = \frac{\text{number of contacts who opened the newsletter}}{\text{number of contacts sent to}} \times 100\%$$

$$\text{Click } \% = \frac{\text{number of contacts who clicked a link in the newsletter}}{\text{number of contacts sent to}} \times 100\%$$

$$\text{Bounce } \% = \frac{\text{number of contacts who could not be reached}}{\text{number of contacts sent to}} \times 100\%$$

$$\text{Unsubscribe } \% = \frac{\text{number of contacts who used newsletter to unsubscribe}}{\text{number of contacts sent to}} \times 100\%$$

We also examine the following characteristics of the newsletters:

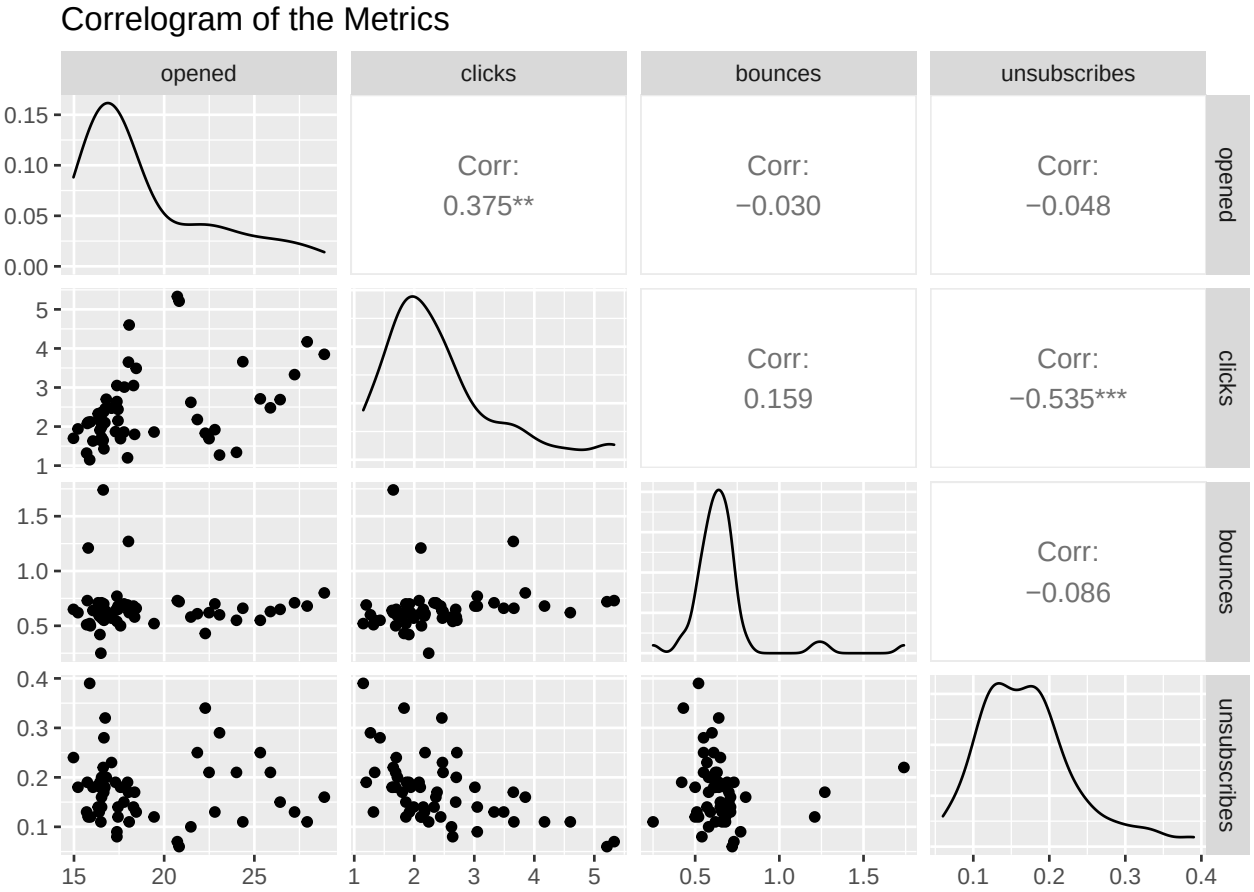
- Trend over the date newsletter was sent out (2019-01-01 to 2020-12-31).
- Whether newsletter was sent before or after start of the COVID pandemic on 2020-03-12.
- Time of day newsletter was sent out (6:30 am to 8:40 pm).
- Length of subject by number of characters.

Below are 5 example newsletters from the dataset, i.e. the 5th, 8th, 25th, 35th, and 47th newsletters sent out.

	datetime	opened	clicks	bounces	unsubscribes
5	2019-05-01 15:21:00	17.97	1.20	0.69	0.19
8	2019-08-05 07:50:00	16.66	1.43	0.55	0.28
25	2020-06-05 07:50:00	17.38	2.64	0.54	0.08
35	2020-08-19 07:05:00	16.53	1.99	0.57	0.14
47	2020-11-11 06:51:00	18.30	3.05	0.68	0.14

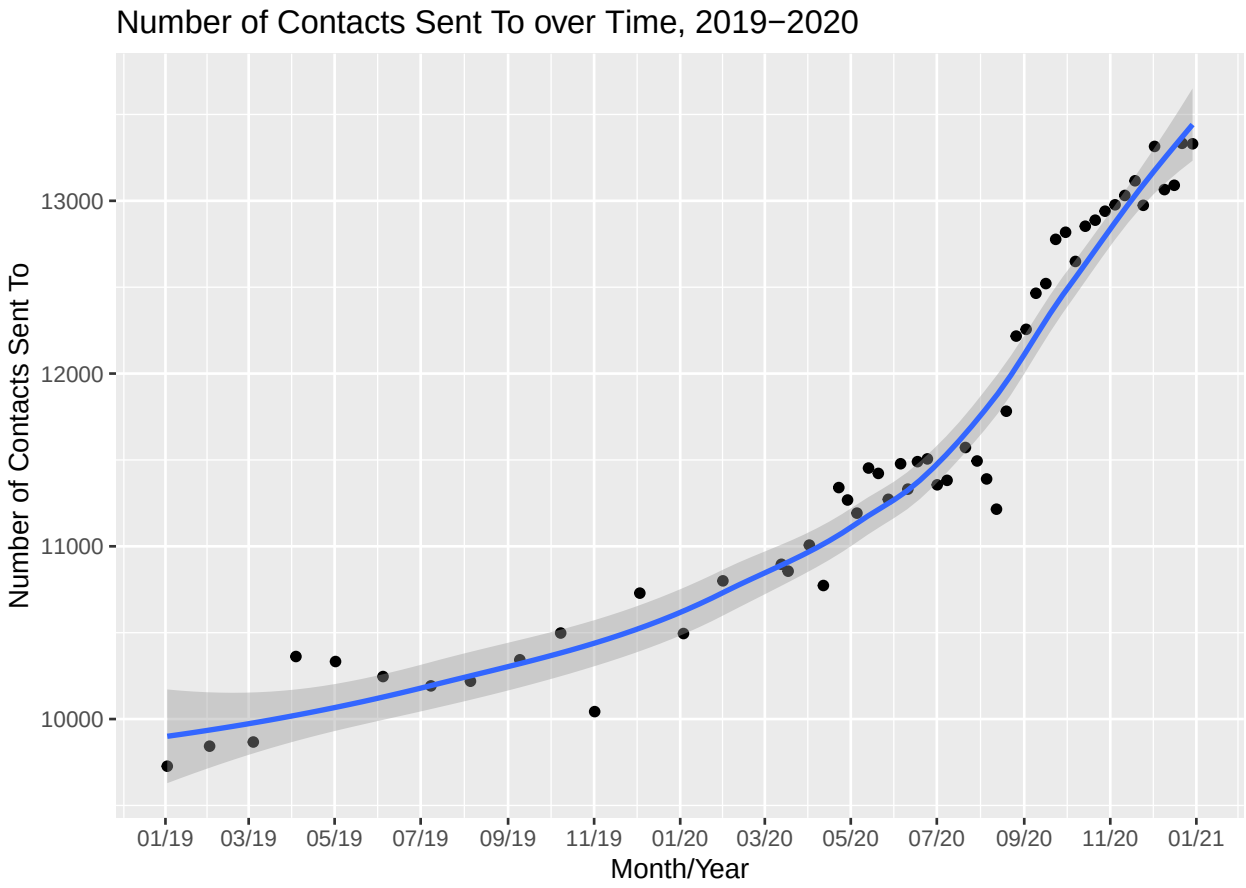
	contacts_sent_to	covid	mins_since_midnight	subject_length
5	10333	Before	921	75
8	10219	Before	470	79
25	11478	After	470	53
35	11782	After	425	76
47	13031	After	411	68

2.2 Correlation of the Metrics

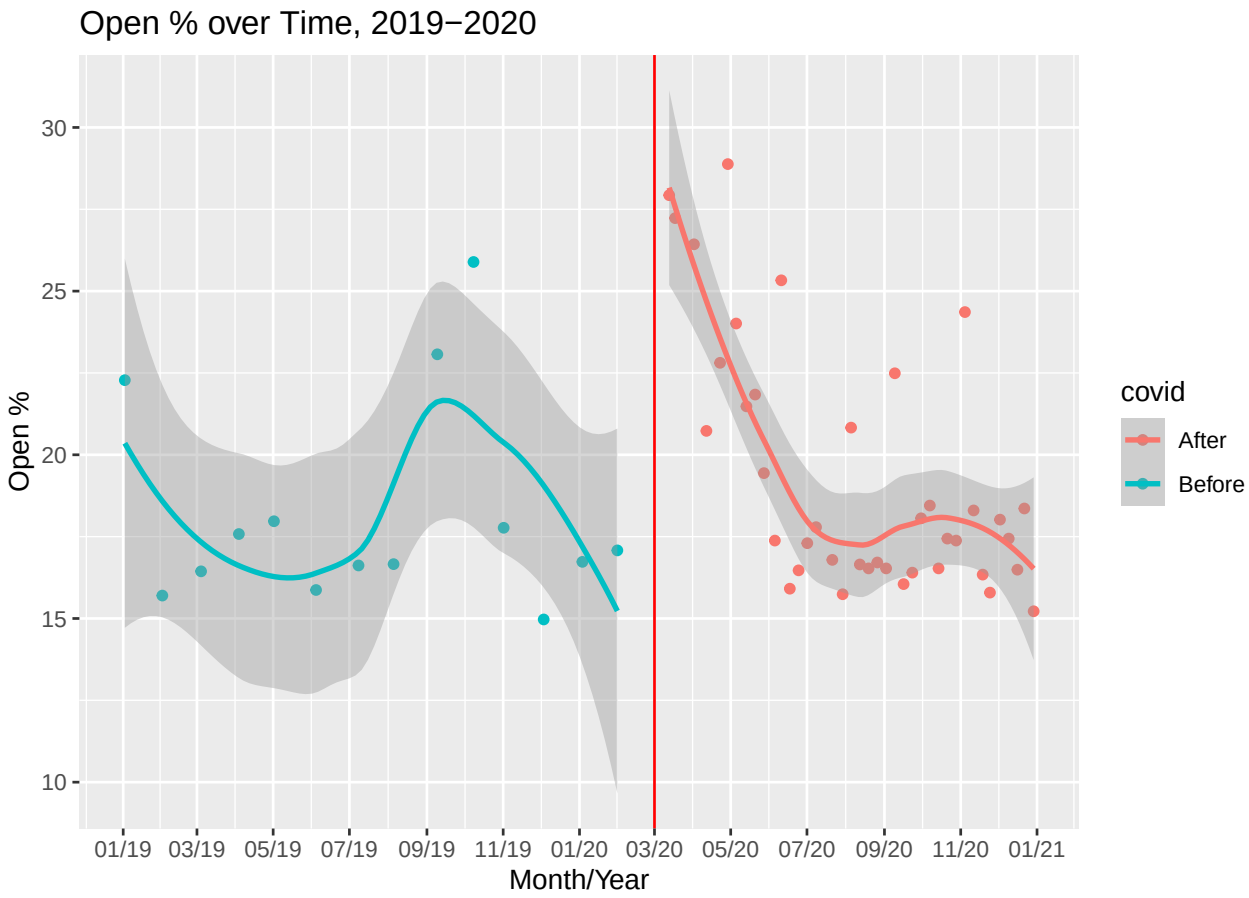


There are two significant correlations: a positive one between opens and clicks, and a negative one between unsubscribes and clicks.

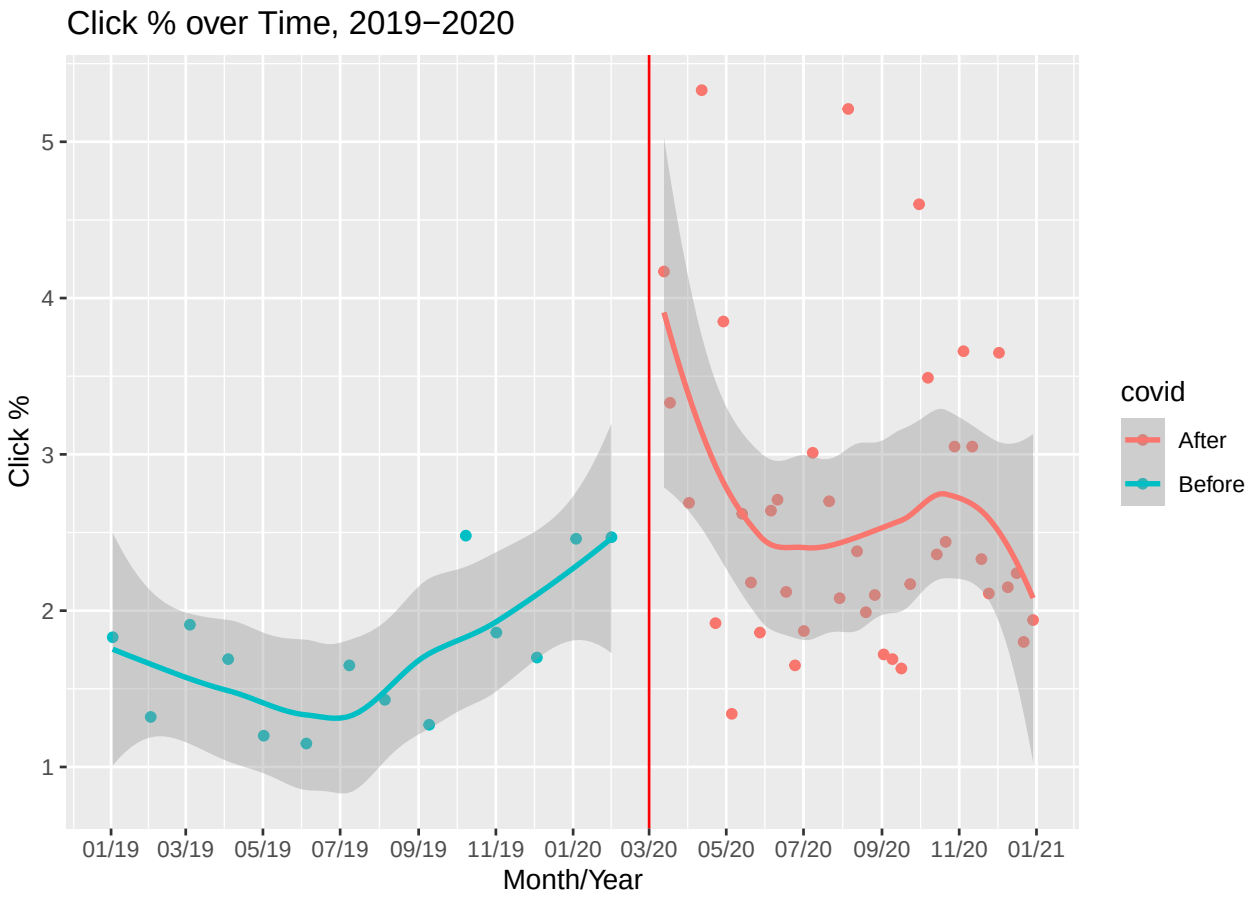
2.3 Summary Statistics over Time, 2019-2020

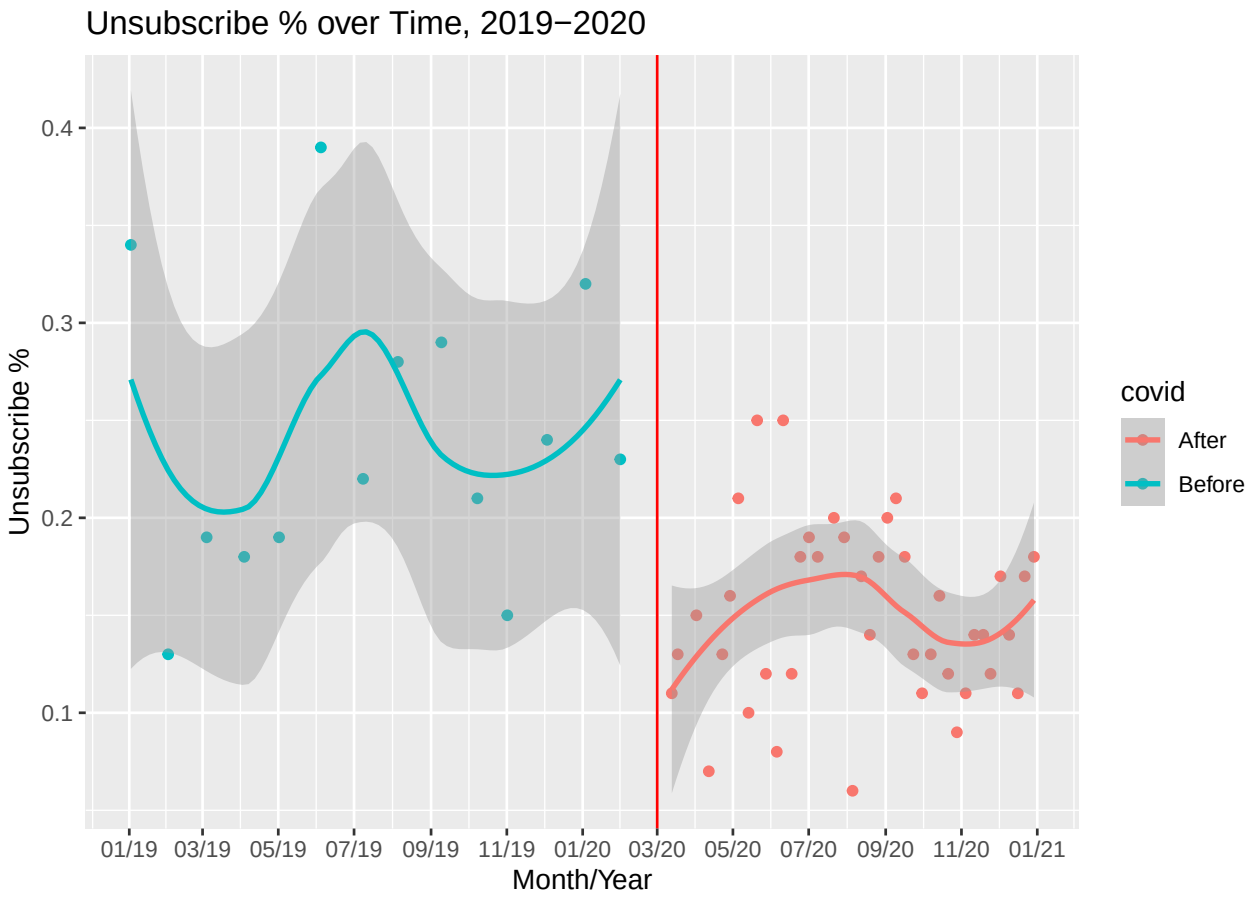


When did the pandemic start changing things? The March 12 weekly newsletter was the first one to mention the COVID-19 pandemic and remote volunteering opportunities.

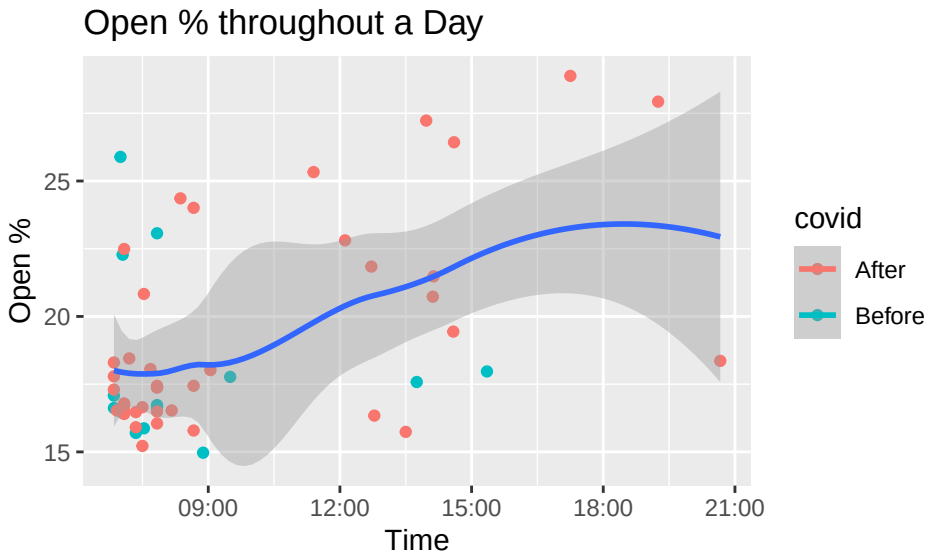


There is a spike in the open % after March.


Click % over Time, 2019−2020
Click %
5
4
3
2
1
01/19
03/19
05/19
07/19
09/19
11/19
01/20
03/20
05/20
07/20
09/20
11/20
01/21
Month/Year
covid
After
Before

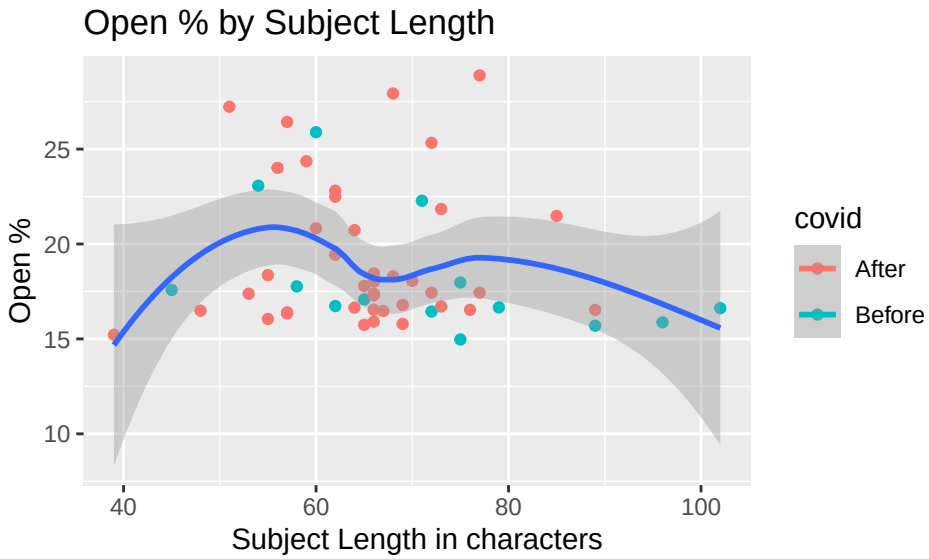


2.4 Summary Statistics throughout a Day



There may be a slight upward trend.

2.5 Effect of Subject Headings



3 Trends in the Open Probability: Executive Summary

3.1 Questions of Interest

- What are the factors that increase the probability of a subscriber opening a newsletter within a week of its send date?
  - What is the best time of day to send a newsletter?
  - Does the email subject affect the open rate?
- How has the COVID pandemic affected the open rate?

3.2 Statistical Analysis

- Barplots to visually display trends
- Statistical model to examine how factors interact
- Results from the model to confirm the trends shown in the barplots

3.3 Takeaways

- Before the pandemic, there was a dip in the open probability when the newsletter was sent at around 10 am. During the pandemic, 10:30 am and 5:10 pm seem to be optimal times for sending the newsletter.
- Shorter subject headings (in terms of number of characters) are better.

4 Trends in the Open Probability: Report

4.1 Overview of the Data Used

There are 16,291 unique subscribers in the data set, with 622,614 observations.

We focused on the probability that a given subscriber will open a weekly newsletter within a week of its sent date. If the subscriber opens the newsletter after a week or uses the newsletter to unsubscribe, we consider it a non-open. We examined several factors affecting the open probability:

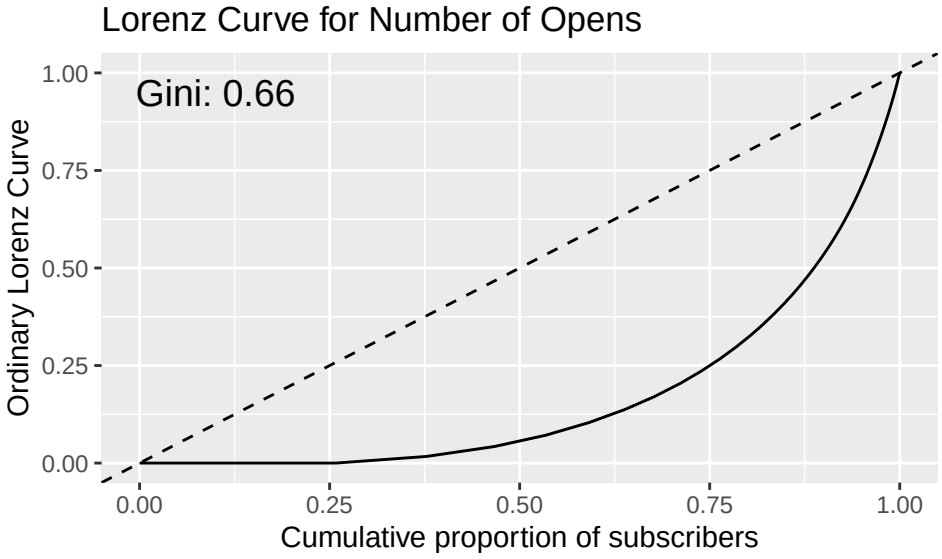
- Trend over the date newsletter was sent out (2019-01-01 to 2020-12-31).
- Whether newsletter was sent before or after start of the COVID pandemic on 2020-03-12.
- Time of day newsletter was sent out (6:30 am to 8:40 pm).
- Length of subject by number of characters.

Below are 10 sample observations from the dataset. Each row corresponds to one of the 622,614 newsletter-subscriber pairs. The last variable, week_open, is the response variable of interest. 1 indicates that the subscriber opened the newsletter within the week; 0 indicates that the subscriber received the newsletter but didn't open it.

date_sent	subscriberid	covid	mins_since_midnight	subject_length	week_open
2020-07-08 06:51:04	70392049	After	411	65	0
2020-07-21 07:05:50	67928039	After	425	69	0
2020-11-18 12:47:35	71244202	After	767	57	0
2020-12-29 07:30:43	70293552	After	450	39	1
2020-06-17 07:21:09	70811658	After	441	66	0
2020-09-23 07:05:42	71567218	After	425	57	1
2020-07-29 13:30:36	67927884	After	810	65	0
2019-12-03 08:53:03	61625847	Before	533	75	0
2019-12-03 08:53:03	57442167	Before	533	75	0
2020-12-16 07:50:15	71567206	After	470	48	0

4.2 Lorenz Curve

The Gini Index ranges from 0 to 1, with 1 being perfect inequality. In this case, the distribution of opens among the subscribers seems unequal; according to the curve, the top 25% of people account for 75% of opens.



4.3 Overview of Analysis

For every factor of interest, we plotted a barplot to display any trends.

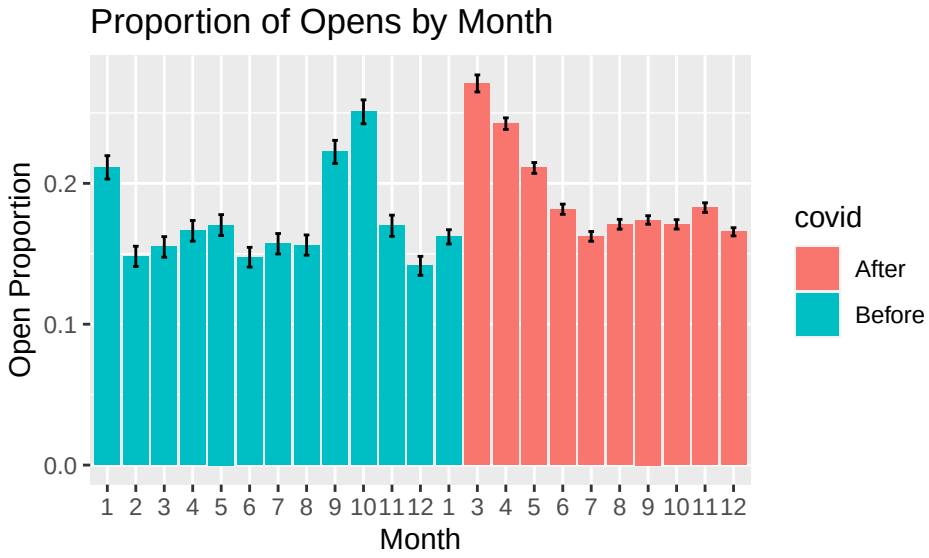
We also fitted a generalized additive mixed model to the data to confirm the trends shown in the barplots. Results from the model are more reliable than just using the barplots, because the model accounts for confounding and dependence between opens for the same subscriber.

The model uses a random sub-sample of 1,629 subscribers (63,897 observations) so it can finish in a reasonable amount of time.

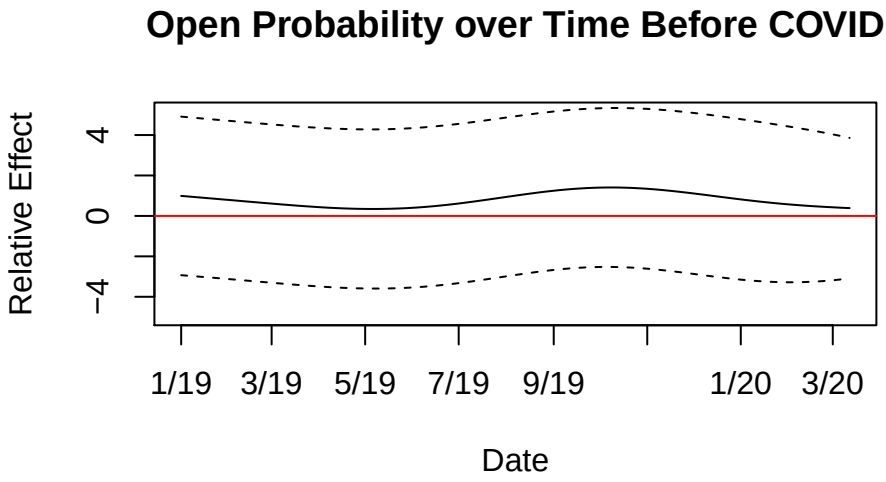
All plots show 95% confidence intervals of the estimates; two standard errors above and below the estimates are indicated on top of the bars in the barplots and by the dashed lines or shading in the line graphs. The true value can be expected to lie within two standard errors from the estimate.

4.4 Trend over Date

The below barplot shows the proportion of subscribers that opened the newsletter, given the month the newsletter was sent to them.

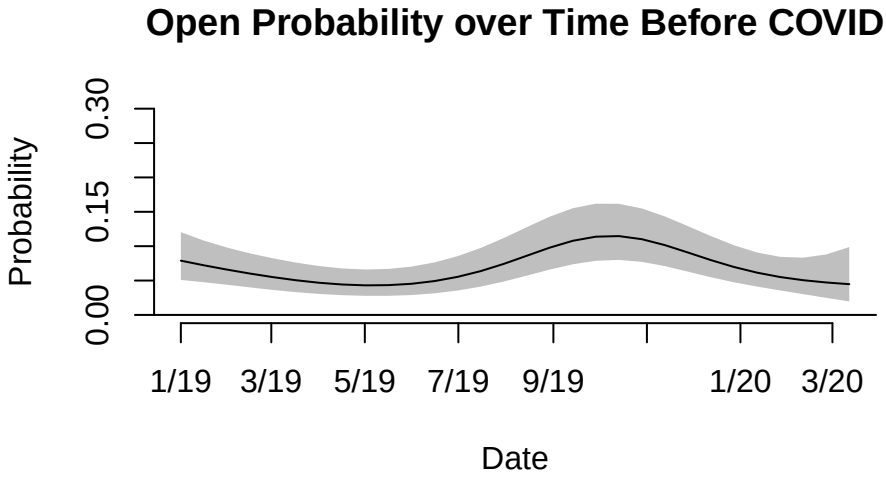


The following plot shows the relative effect of the date the newsletter is sent out on the open probability (a negative relative effect corresponds to a decrease in probability, and a positive relative effect corresponds to an increase in probability) before the pandemic. The red line at zero indicates no effect. There appears to be a seasonal trend.

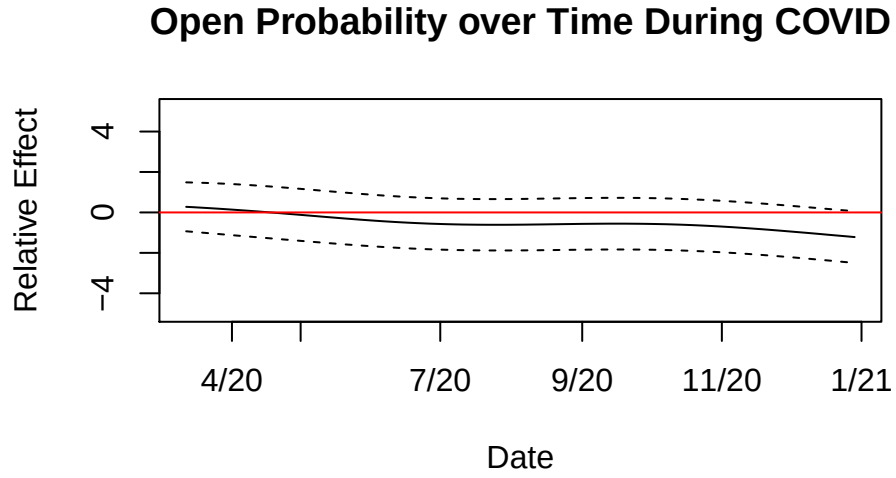


The above plot shows the partial effect of the date alone, without considering other covariates. The following plot shows the actual estimated probabilities over time under the following specific scenario:

- The newsletter was sent out at 10:30 am.
- The newsletter has the median subject length of 66 characters.

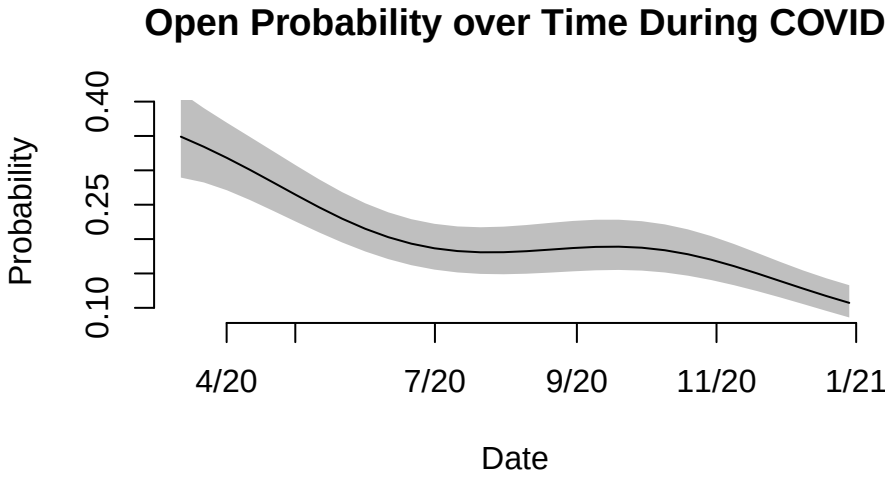


After the pandemic, there is a downward trend in open probability.



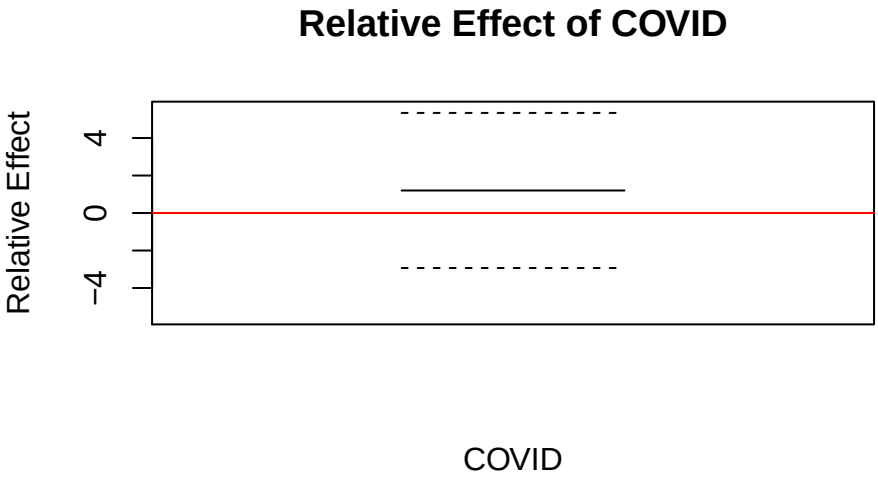
The above plot shows the partial effect of the date alone, without considering other covariates. The following plot shows the actual estimated probabilities over time under the following specific scenario:

- The newsletter was sent out at 10:30 am.
- The newsletter has the median subject length of 66 characters.



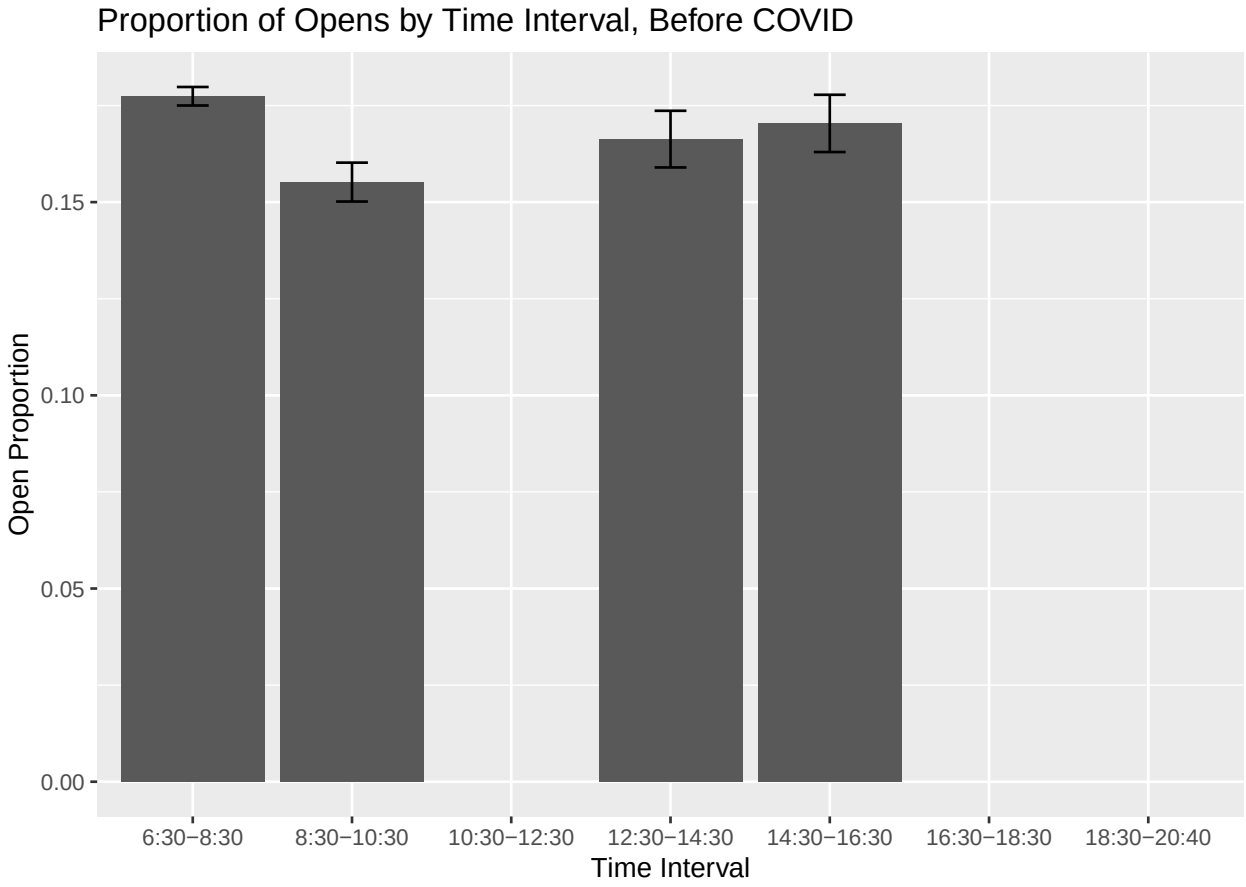
Below shows the relative effect of COVID (solid line), i.e. whether the newsletter was sent after the pandemic started. It appears that the open probability rises after the pandemic starts, but the effect is not significant

(see the dashed standard error bars). However, COVID significantly affects how the open probability varies by date or hour of day the newsletter was sent.

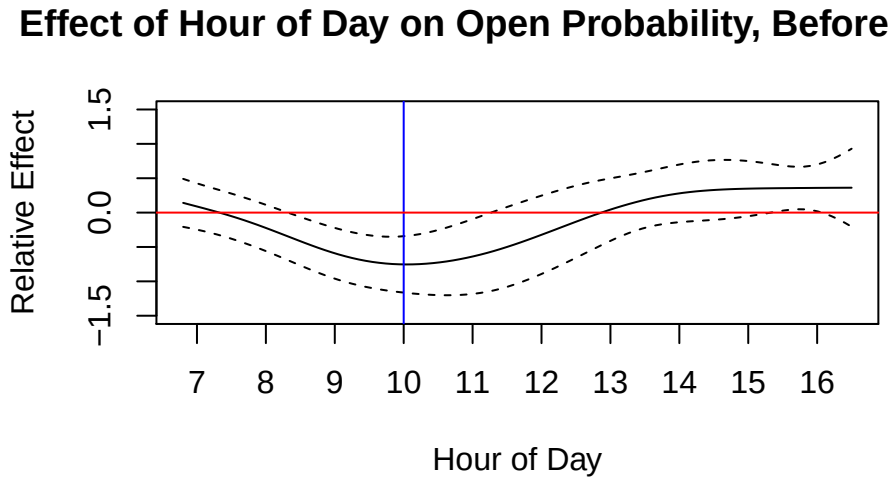


4.5 Time of Day Trend, Before COVID

The below barplot shows the proportion of subscribers that opened the newsletter sent before the pandemic, given that the newsletter was sent to them within a specific time interval. There were no newsletters sent in three of the time intervals, so the bars are absent.

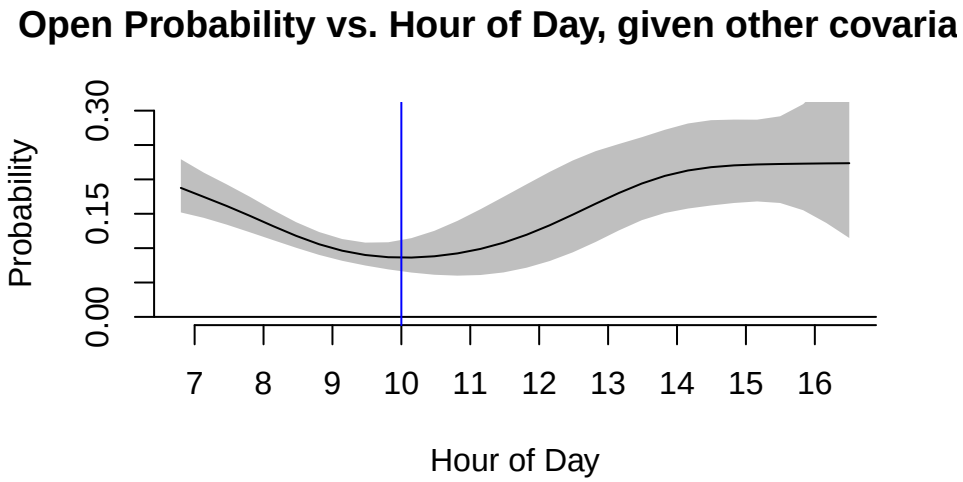


The following plot shows the relative effect of the time of day the newsletter is sent out on the open probability (a negative relative effect corresponds to a decrease in probability, and a positive relative effect corresponds to an increase in probability) before the pandemic. It appears that there is a dip in the open probability at about 10 am.



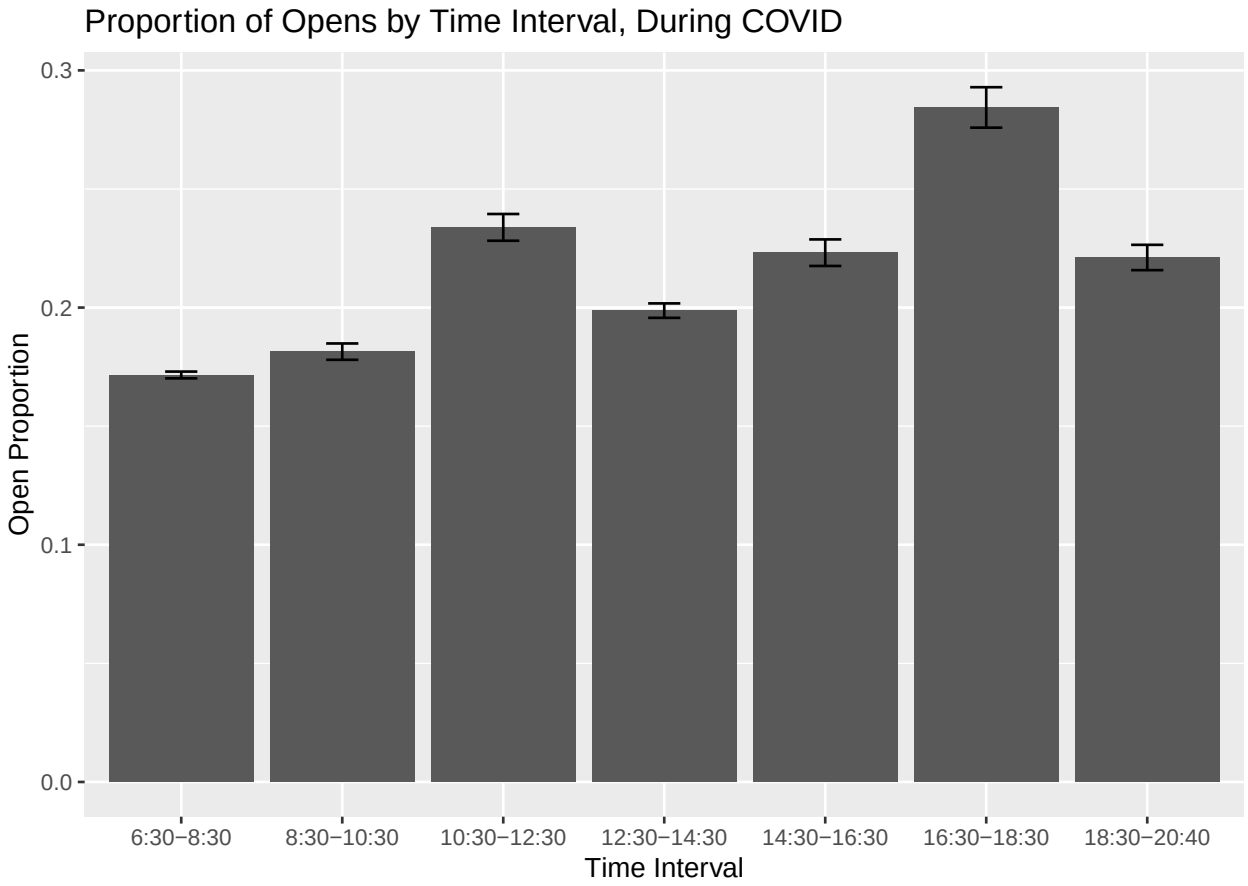
The above plot shows the partial effect of the time of day alone, without considering other covariates. The following plot shows the actual estimated probabilities by time of day under the following specific scenario:

- The newsletter was sent out on December 1, 2019.
- The newsletter has the median subject length of 66 characters.

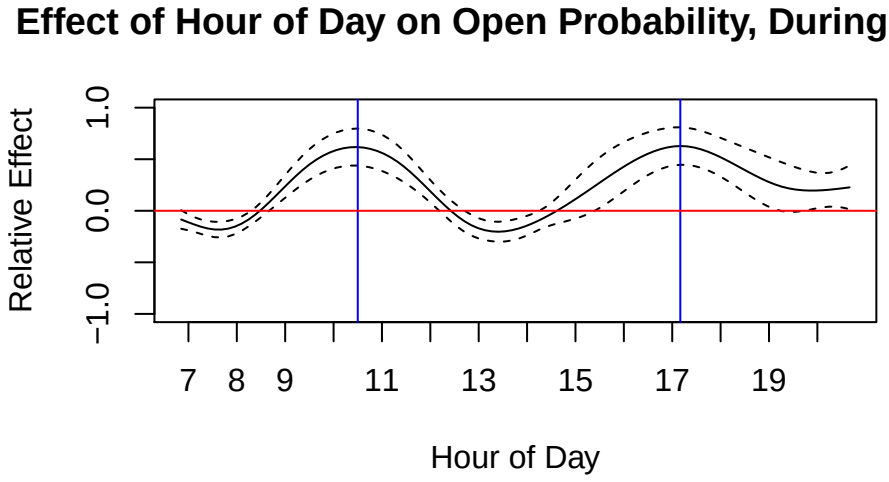


4.6 Time of Day Trend, During COVID

The below barplot shows the proportion of subscribers that opened the newsletter during the pandemic, given that the newsletter was sent to them within a specific time interval. The barplot suggests that there are two time intervals with higher open proportions.

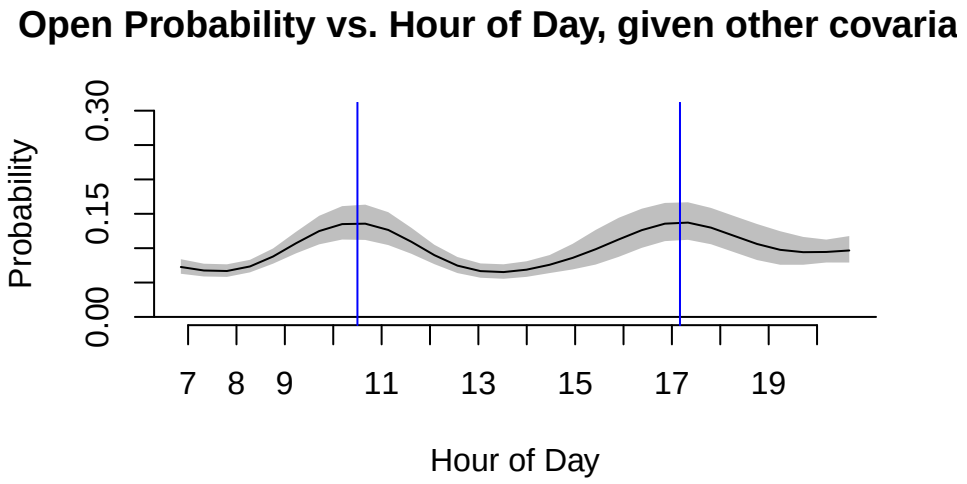


The following plot shows the relative effect of the time of day the newsletter is sent out on the open probability during the pandemic. It appears that the optimal times are about 10:30 in the morning and 17:10 in the evening.



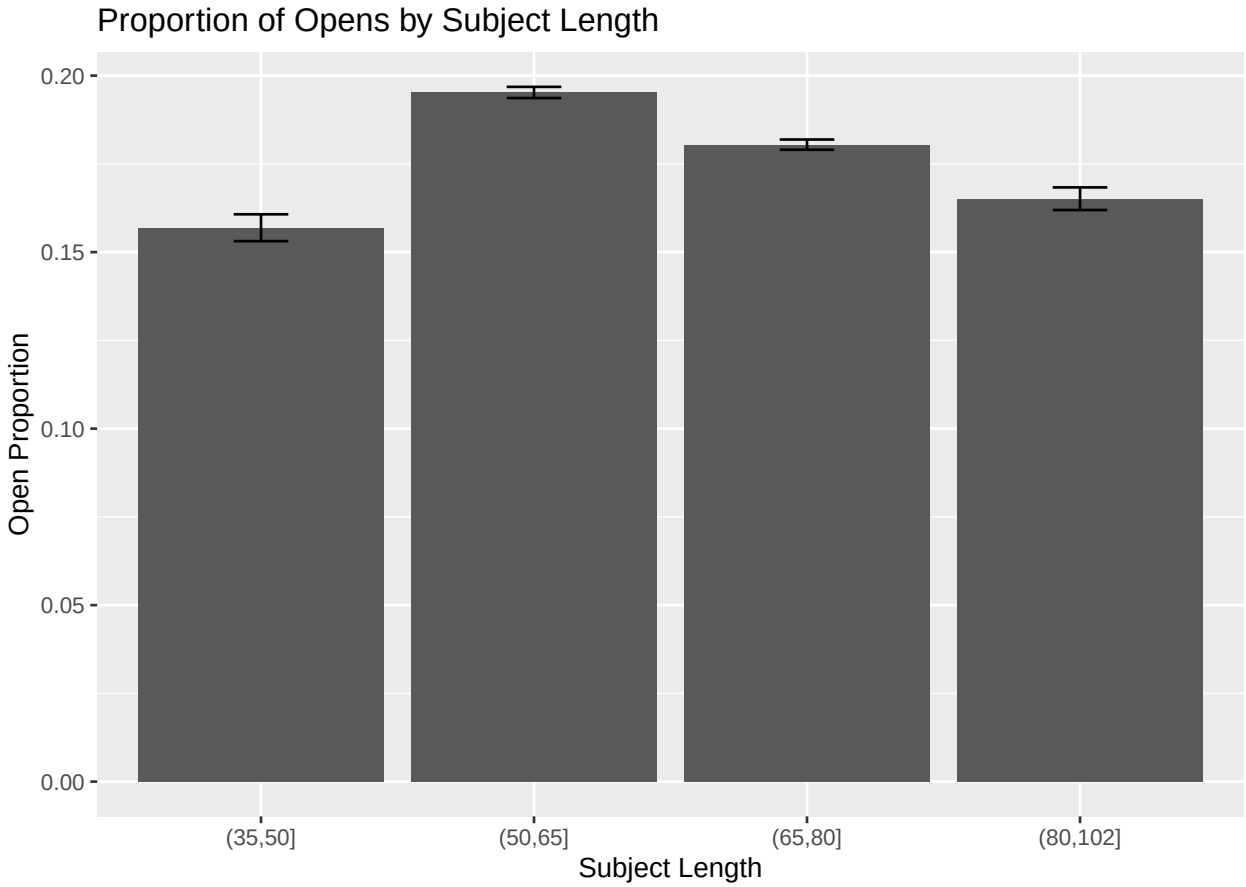
The above plot shows the partial effect of the time of day alone, without considering other covariates. The following plot shows the actual estimated probabilities by time of day under the following specific scenario:

- The newsletter was sent out on December 1, 2020.
- The newsletter has the median subject length of 66 characters.

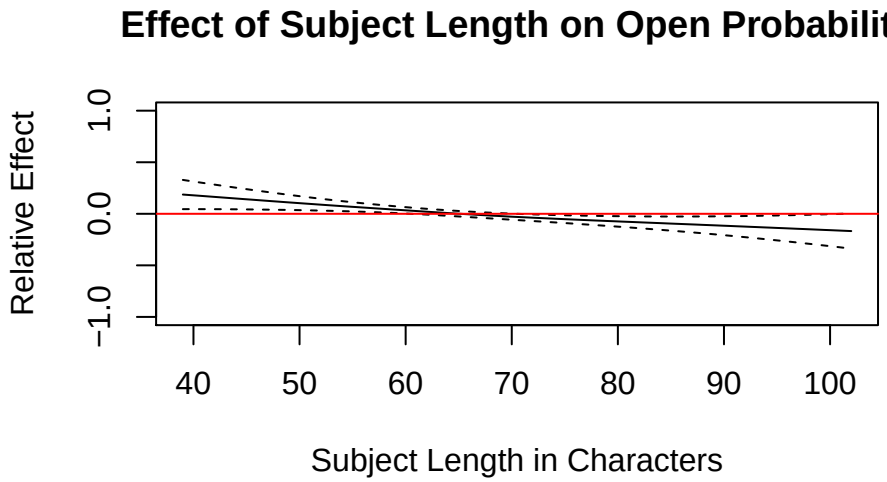


4.7 Subject Length Trend

The below barplot shows the proportion of subscribers that opened the newsletter, given that the subject length was within a specific interval.

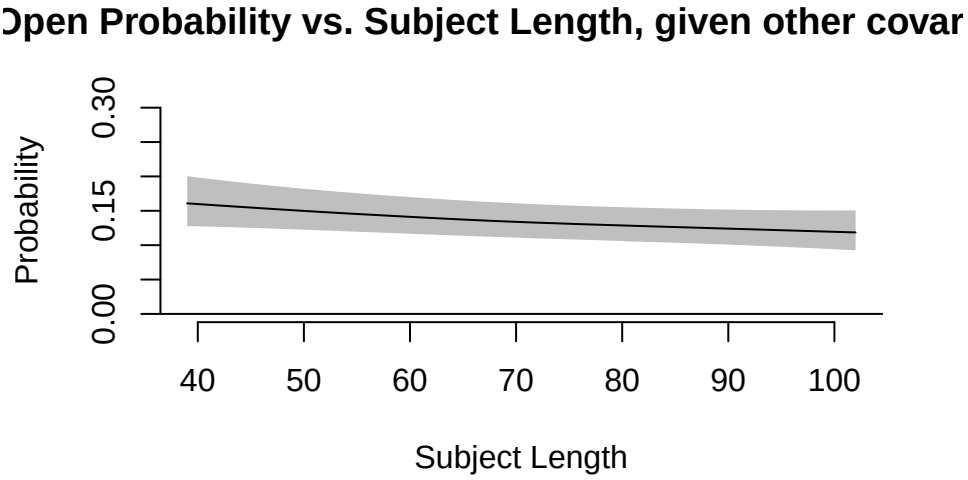


The following plot shows the relative effect of the subject length on the open probability. There appears to be a downward trend in open probability as the subject length increases.



The above plot shows the partial effect of the subject length alone, without considering other covariates. The following plot shows the actual estimated probabilities by subject length under the following specific scenario:

- The newsletter was sent out on December 1, 2020.
- The newsletter was sent out at 10:30 am.



5 Trends in the Click Probability: Executive Summary

5.1 Questions of Interest

- What are the factors that increase the probability of a subscriber clicking on any link in a newsletter?
  - Does the time of day the newsletter is sent affect the click rate?
  - Does the email subject affect the click rate?
  - Does the content of the newsletter (word count, number of links, number of pictures) affect the click rate?
- How has the COVID pandemic affected the click rate?

5.2 Statistical Analysis

- Barplots to visually display trends
- Statistical model to examine how factors interact
- Results from the model to confirm the trends shown in the barplots

5.3 Takeaways

- Because the click probability is already quite low, changing the time of day or subject length would not affect the click probability as much as it would affect the open probability. Thus, we recommend trying to increase the open rate before trying to change the click rate with those factors.
- Before the pandemic, there were less clicks if the newsletter was sent around 9 am and more clicks if the newsletter was sent around 1 pm. However, during the pandemic, the time of day the newsletter was sent didn't affect the click rate.
- A subject length of 70 characters leads to the most clicks.
- A higher word count is associated with less clicks.
- More text or image links lead to more clicks.
- The optimal number of clickable pictures appears to be 8. More clickable pictures is not necessarily better.

6 Trends in the Click Probability: Report

6.1 Overview of the Data Used

There are 16,291 unique subscribers in the data set, with 622,614 observations.

We focused on the probability that a given subscriber will click on at least one link in a given newsletter. In addition to the variables used in the open probability model,

- Trend over the date newsletter was sent out (2019-01-01 to 2020-12-31).
- Whether newsletter was sent before or after start of the COVID pandemic on 2020-03-12.
- Time of day newsletter was sent out (6:30 am to 8:40 pm).
- Length of subject by number of characters.

we also look at the following factors related to the content within the newsletter:

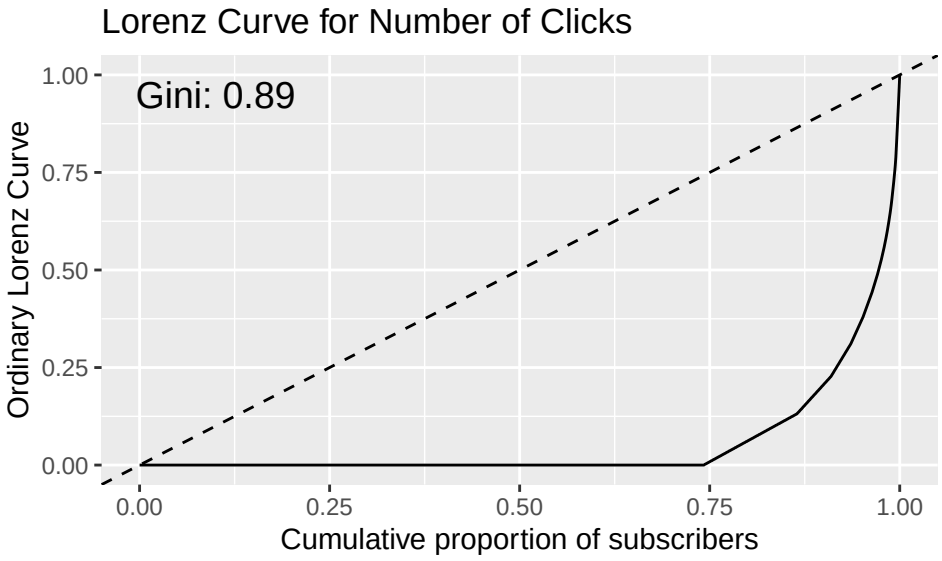
- Number of words in newsletter.
- Number of links (text or image) in newsletter.
- Number of clickable pictures in newsletter.
- Number of unclickable pictures in newsletter.

Below are 10 sample observations from the dataset, containing the four "content" variables mentioned above. Each row corresponds to one of the 622,614 newsletter-subscriber pairs. The last variable, clicks, is the response variable of interest. 1 indicates that the subscriber clicked on any link in a given newsletter; 0 indicates that the subscriber didn't click on any link in a given newsletter.

num_words	num_links	num_clickable_pics	num_unclickable_pics	clicks
347	23	6	0	0
410	23	6	1	0
402	28	8	0	0
512	30	9	0	0
333	20	6	0	0
357	30	13	0	0
382	26	6	0	0
484	31	7	3	0
484	31	7	3	0
513	27	8	0	0

6.2 Lorenz Curve

The Gini Index ranges from 0 to 1, with 1 being perfect inequality. In this case, the distribution of clicks among the subscribers seems unequal; according to the curve, only 25% of subscribers click at all, and the top 10% of people account for 75% of clicks.



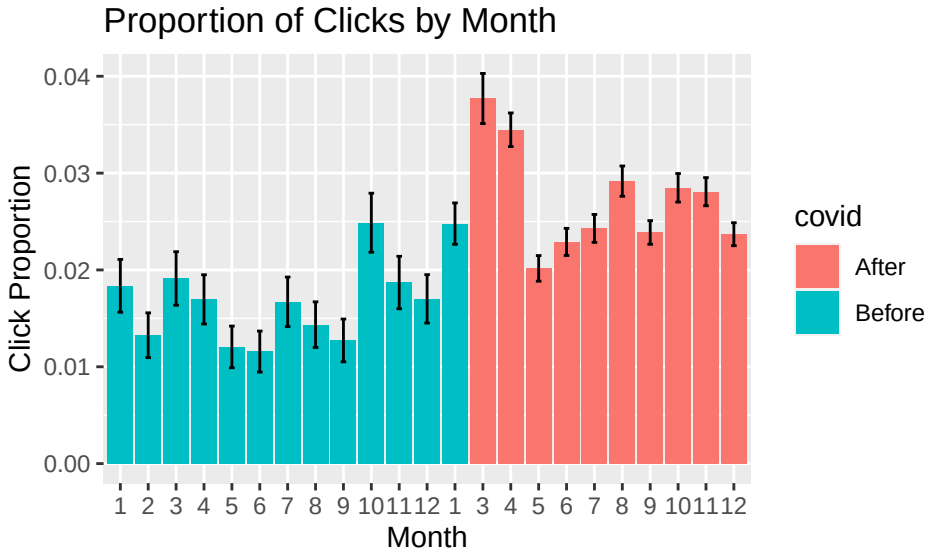
6.3 Overview of Analysis

The generalized additive mixed model uses a random sub-sample of 1,629 subscribers (63,897 observations) so it can finish in a reasonable amount of time.

All plots show 95% confidence intervals of the estimates; two standard errors above and below the estimates are indicated on top of the bars in the barplots and by the dashed lines or shading in the line graphs. The true value can be expected to lie within two standard errors from the estimate.

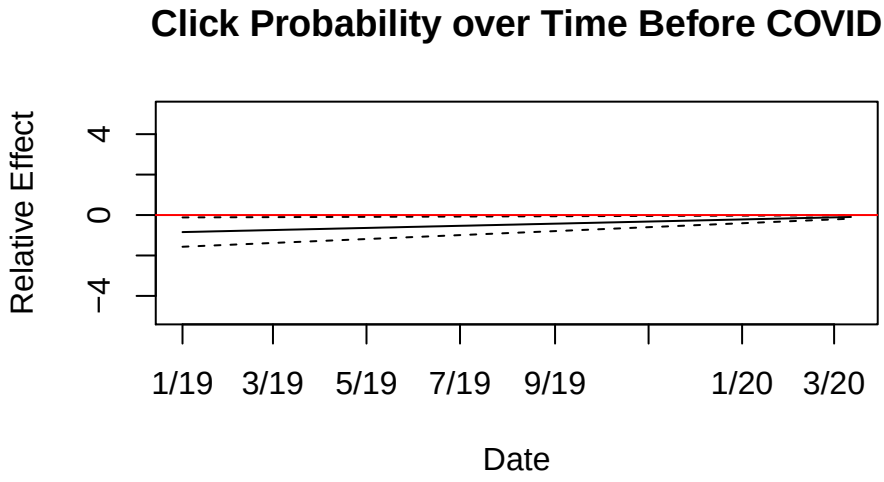
6.4 Trend over Date

The below barplot shows the proportion of subscribers that clicked on a link in the newsletter, given the month the newsletter was sent to them.



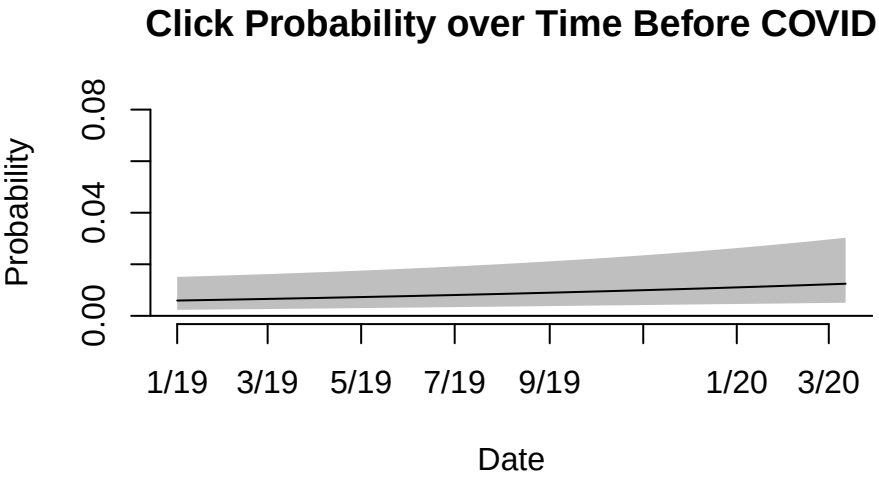
The following plot shows the relative effect of the date the newsletter is sent out on the click probability (a negative relative effect corresponds to a decrease in probability, and a positive relative effect corresponds

to an increase in probability) before the pandemic. There is a slight increase over time leading up to the pandemic.

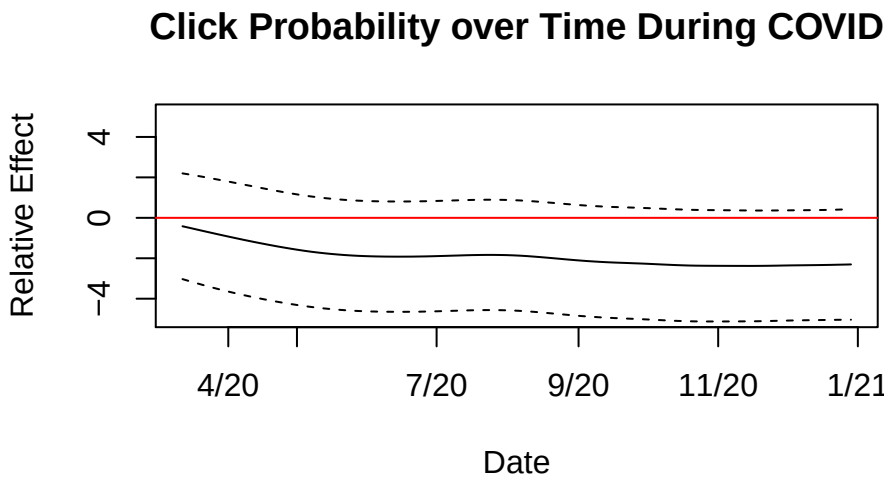


The above plot shows the partial effect of the date alone, without considering other covariates. The following plot shows the actual estimated probabilities over time under the following specific scenario:

- The newsletter was sent out at 10:30 am.
- The newsletter has the median subject length of 66 characters.
- The newsletter has the median number of words at 392 words.
- The newsletter has the median number of links at 24 links.
- The newsletter has the median number of clickable pictures at 7.
- The newsletter has the median number of unclickable pictures at 0.

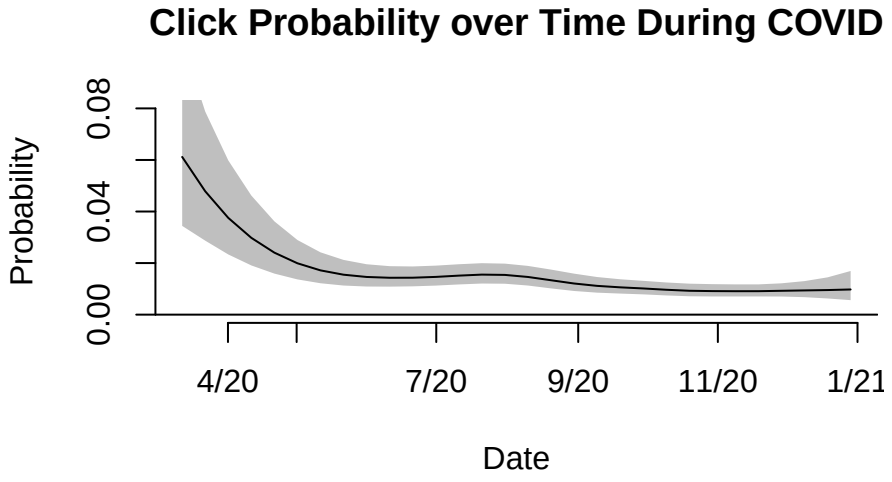


After the pandemic, there is a downward trend in click probability.

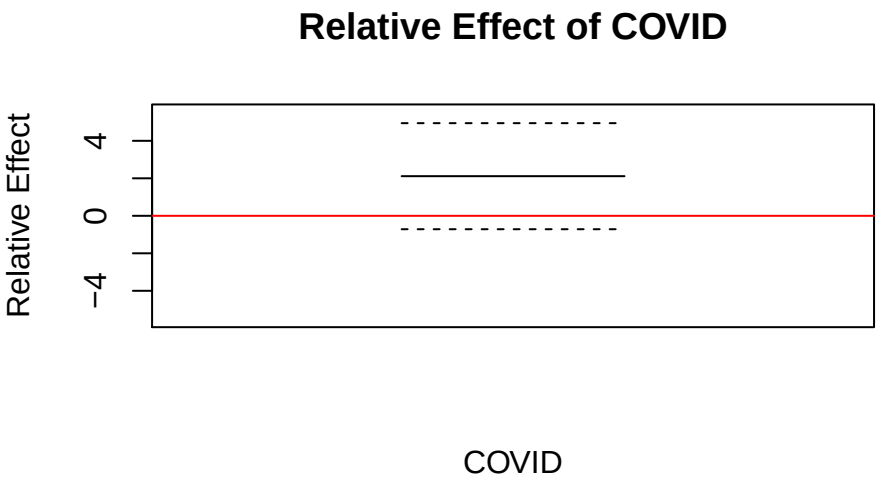


The above plot shows the partial effect of the date alone, without considering other covariates. The following plot shows the actual estimated probabilities over time under the following specific scenario:

- The newsletter was sent out at 10:30 am.
- The newsletter has the median subject length of 66 characters.
- The newsletter has the median number of words at 392 words.
- The newsletter has the median number of links at 24 links.
- The newsletter has the median number of clickable pictures at 7.
- The newsletter has the median number of unclickable pictures at 0.

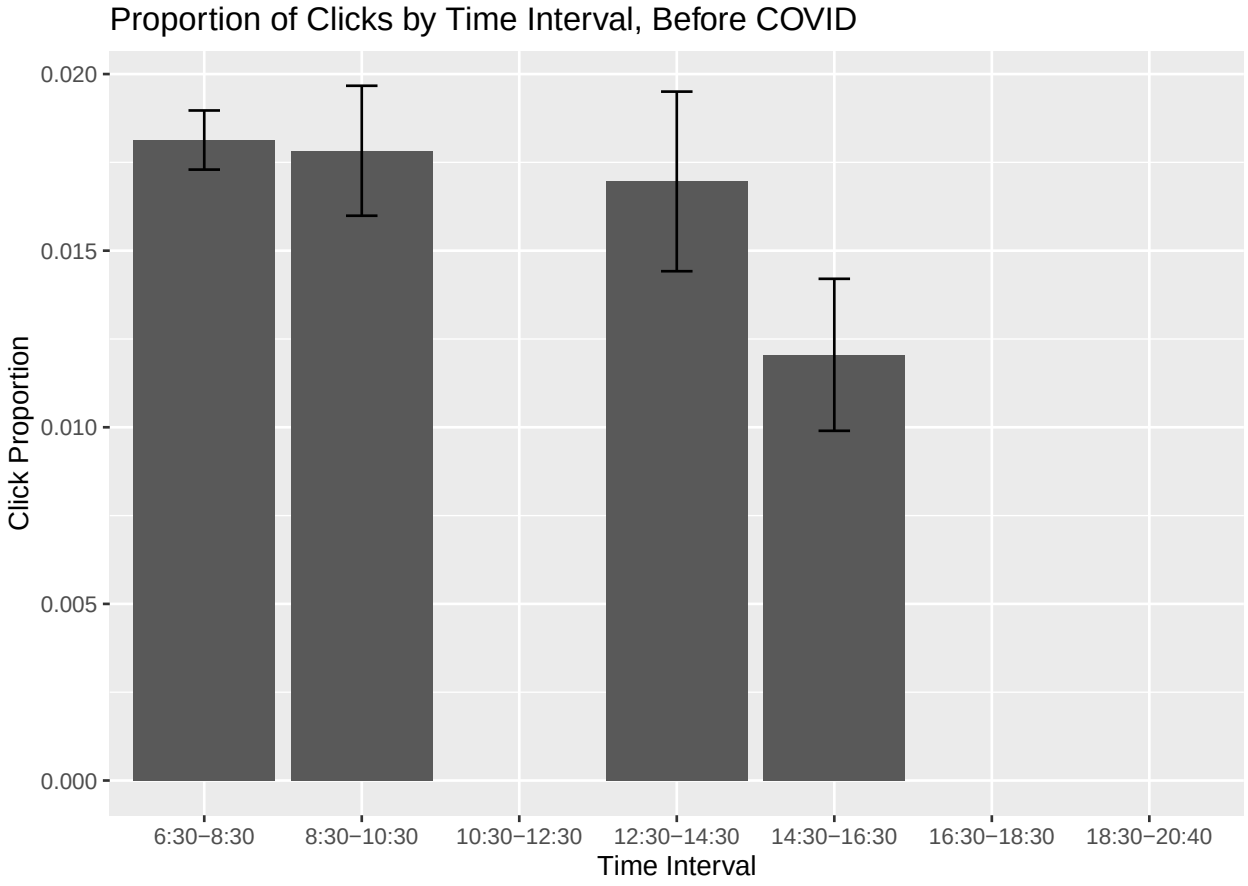


Below shows the relative effect of COVID (solid line), i.e. whether the newsletter was sent after the pandemic started. It appears that the click probability rises after the pandemic starts, but the effect is not significant (see the dashed standard error bars). However, COVID significantly affects how the click probability varies by date or hour of day the newsletter was sent.



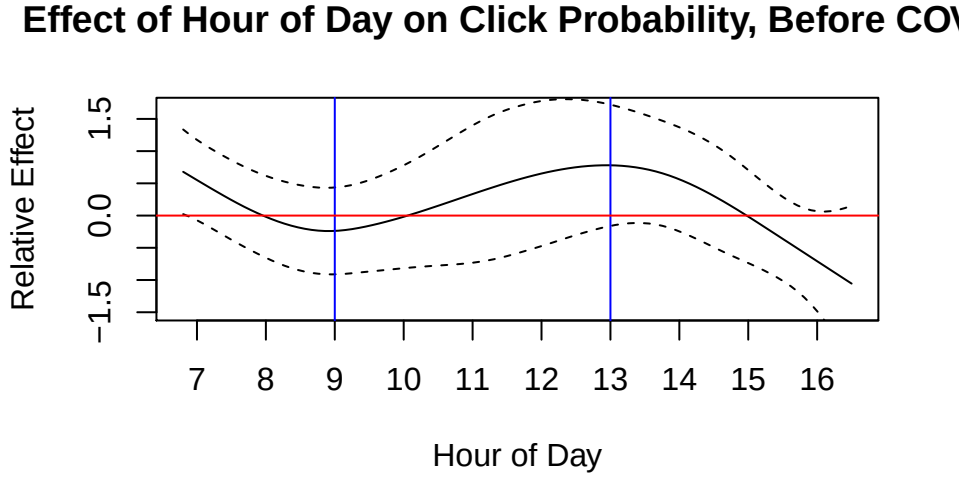
6.5 Time of Day Trend, Before COVID

The below barplot shows the proportion of subscribers that clicked on a link in the newsletter sent before the pandemic, given that the newsletter was sent to them within a specific time interval. There were no newsletters sent in three of the time intervals, so the bars are absent.



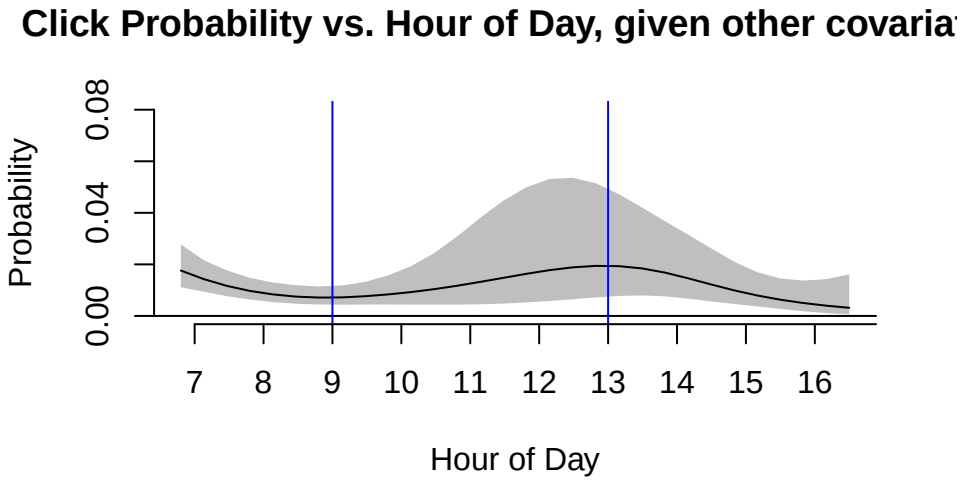
The following plot shows the relative effect of the time of day the newsletter is sent out on the click probability (a negative relative effect corresponds to a decrease in probability, and a positive relative effect corresponds to an increase in probability) before the pandemic.

It appears that there is a dip in the click probability at about 9 am, whereas there is a rise at about 1 pm.



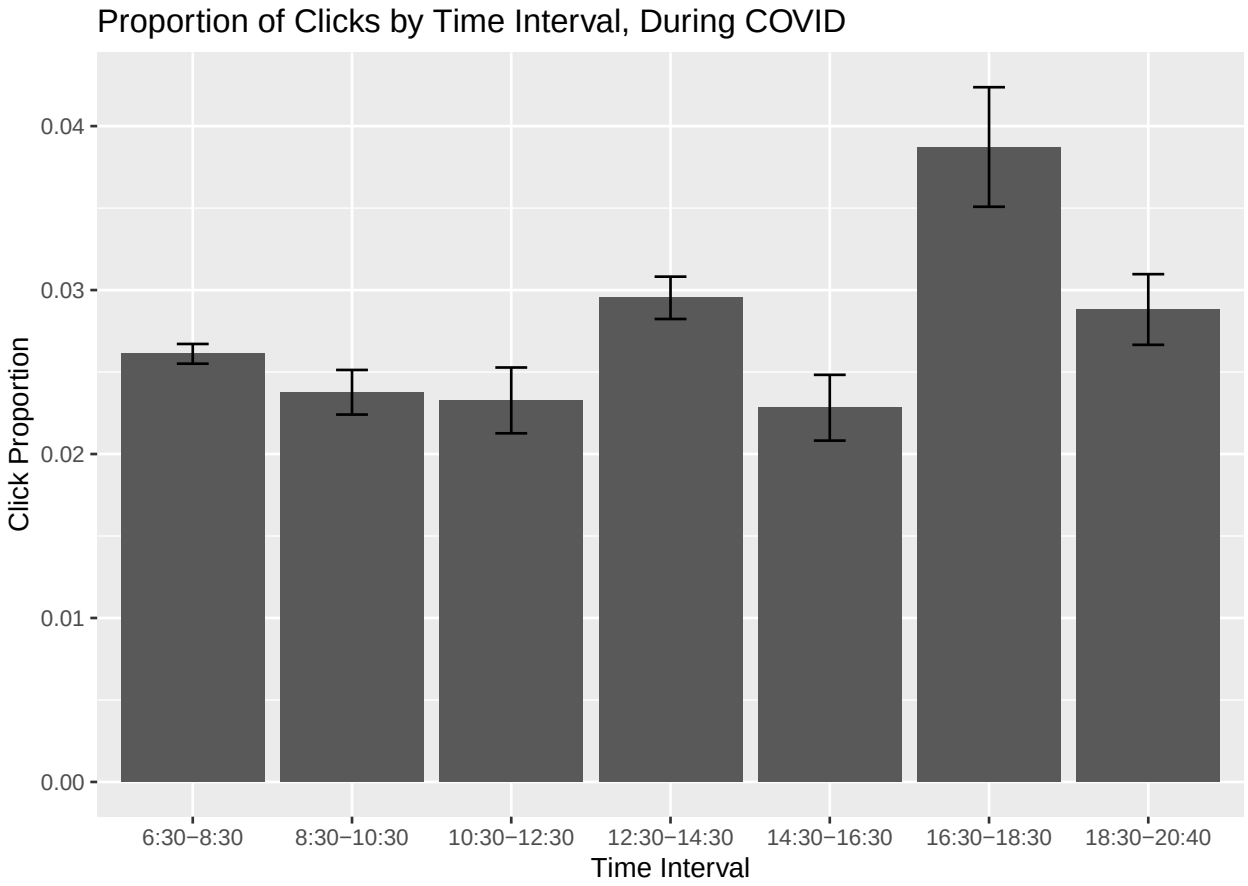
The above plot shows the partial effect of the time of day alone, without considering other covariates. The following plot shows the actual estimated probabilities by time of day under the following specific scenario:

- The newsletter was sent out on December 1, 2019.
- The newsletter has the median subject length of 66 characters.
- The newsletter has the median number of words at 392 words.
- The newsletter has the median number of links at 24 links.
- The newsletter has the median number of clickable pictures at 7.
- The newsletter has the median number of unclickable pictures at 0.

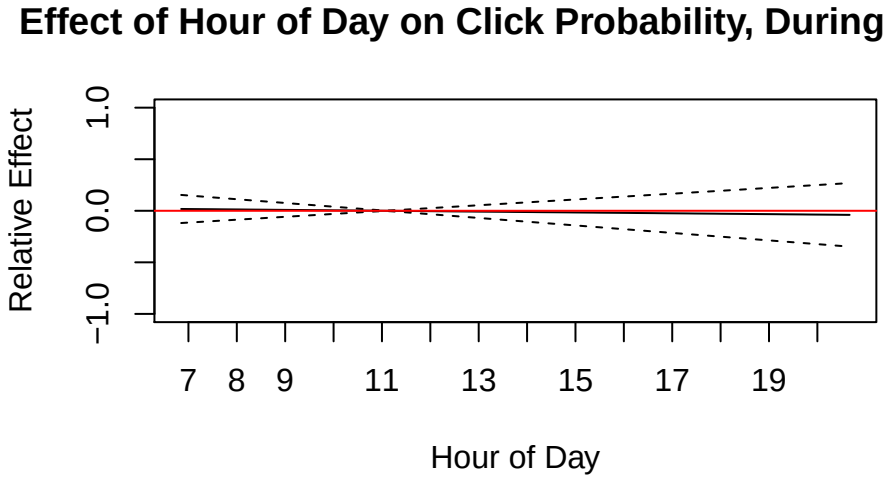


6.6 Time of Day Trend, During COVID

The below barplot shows the proportion of subscribers that clicked on a link in the newsletter sent during the pandemic, given that the newsletter was sent to them within a specific time interval.



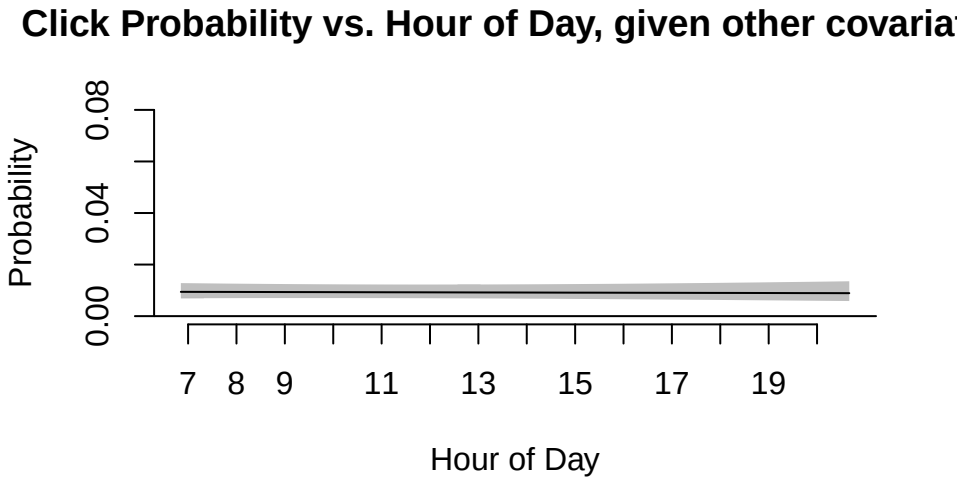
The following plot shows the relative effect of the time of day the newsletter is sent out on the click probability during the pandemic. During the pandemic, the time of day the newsletter is sent has no discernible effect on the click probability.



The above plot shows the partial effect of the time of day alone, without considering other covariates. The following plot shows the actual estimated probabilities by time of day under the following specific scenario:

- The newsletter was sent out on December 1, 2020.
- The newsletter has the median subject length of 66 characters.
- The newsletter has the median number of words at 392 words.
- The newsletter has the median number of links at 24 links.

- The newsletter has the median number of clickable pictures at 7.
- The newsletter has the median number of unclickable pictures at 0.

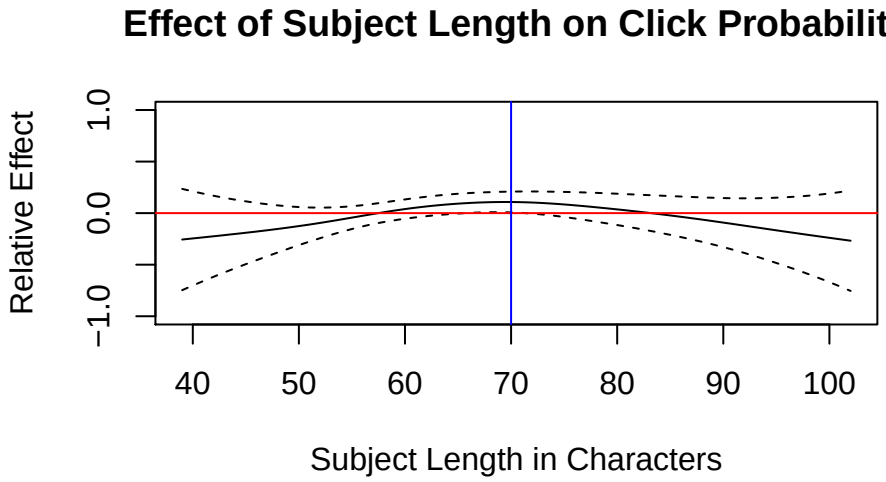


6.7 Subject Length Trend

The below barplot shows the proportion of subscribers that clicked on a link in the newsletter, given that the subject length was within a specific interval.

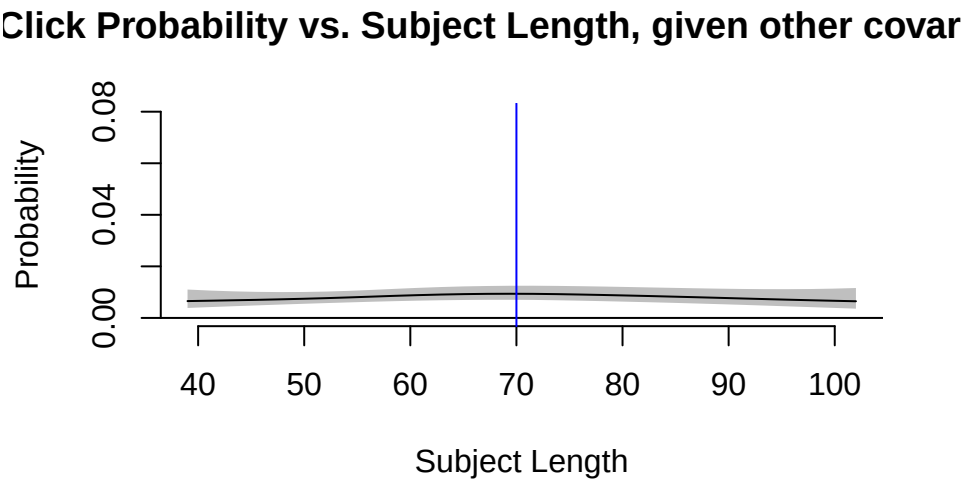
The following plot shows the relative effect of the subject length on the click probability. The maximum click

probability corresponds to a subject length of approximately 70 characters.



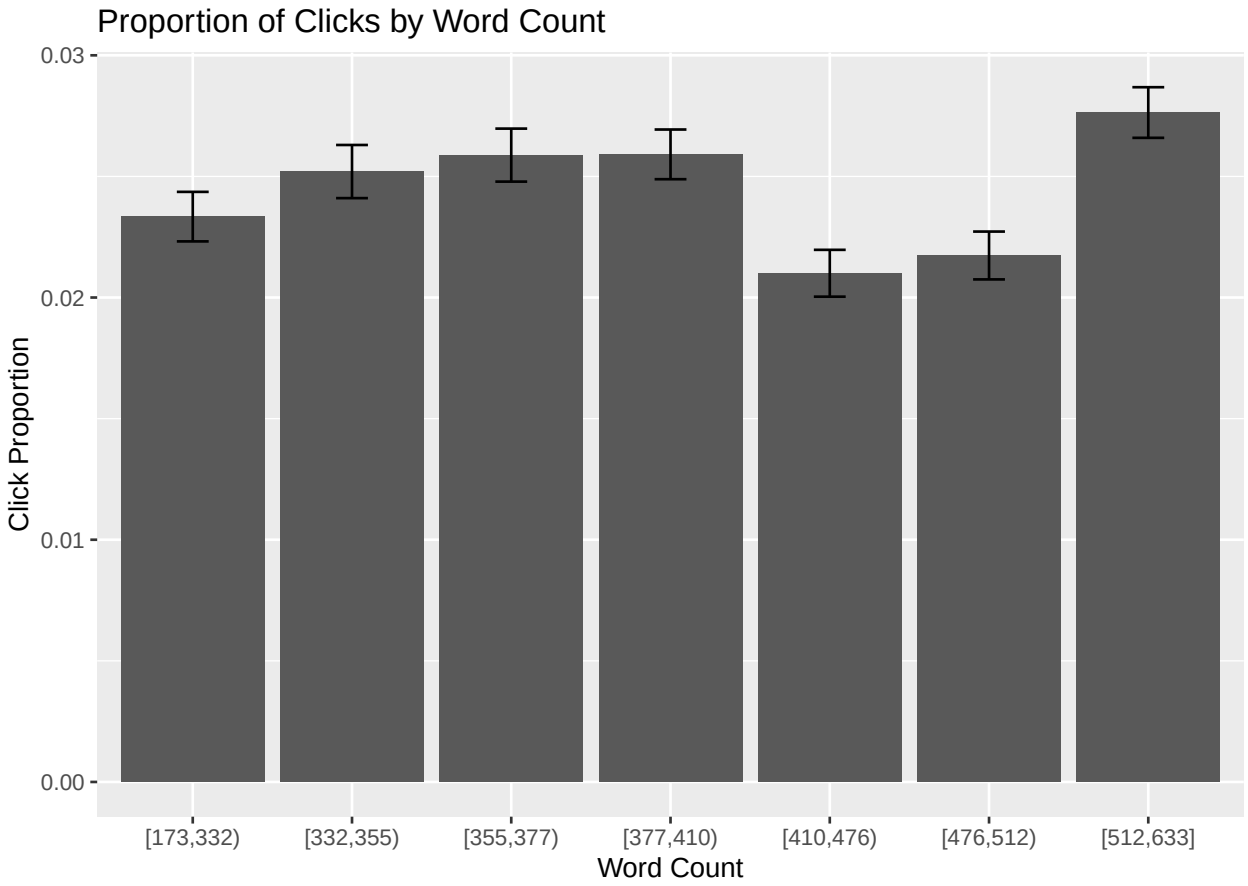
The above plot shows the partial effect of the subject length alone, without considering other covariates. The following plot shows the actual estimated probabilities by subject length under the following specific scenario:

- The newsletter was sent out on December 1, 2020.
- The newsletter was sent out at 10:30 am.
- The newsletter has the median number of words at 392 words.
- The newsletter has the median number of links at 24 links.
- The newsletter has the median number of clickable pictures at 7.
- The newsletter has the median number of unclickable pictures at 0.

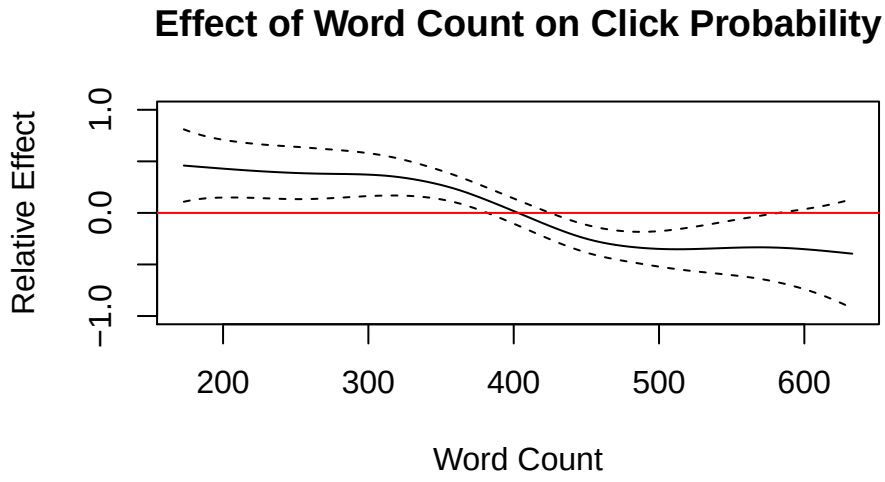


6.8 Word Count Trend

The below barplot shows the proportion of subscribers that clicked on a link in the newsletter, given that the newsletter word count was within a specific interval.



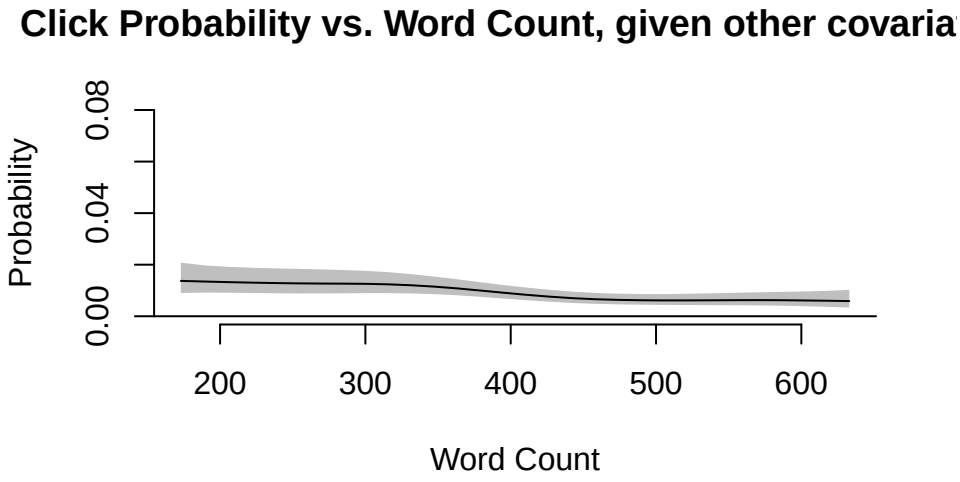
The following plot shows the relative effect of the word count on the click probability. There appears to be a downward trend in click probability as the word count increases.



The above plot shows the partial effect of the word count alone, without considering other covariates. The following plot shows the actual estimated probabilities by word count under the following specific scenario:

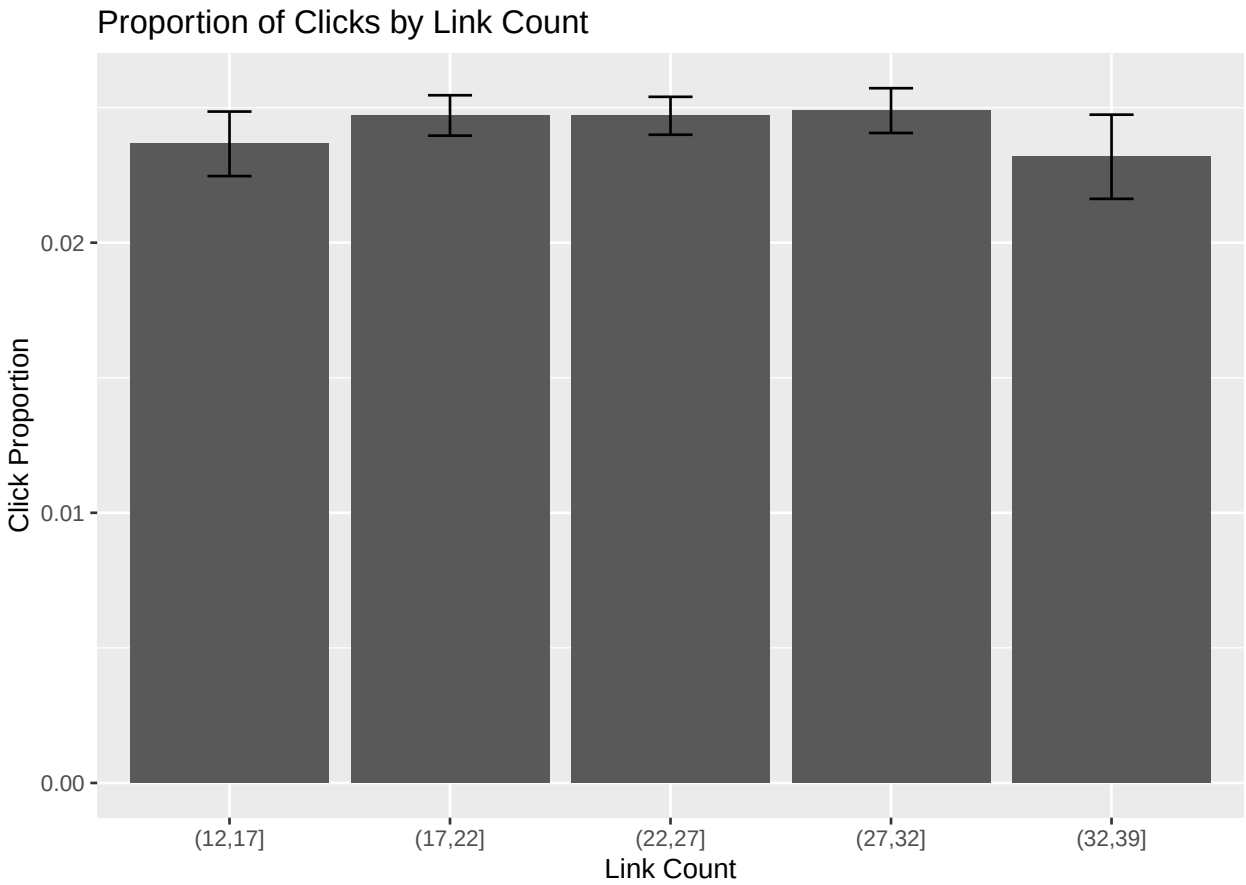
- The newsletter was sent out on December 1, 2020.
- The newsletter was sent out at 10:30 am.
- The newsletter has the median subject length of 66 characters.
- The newsletter has the median number of links at 24 links.
- The newsletter has the median number of clickable pictures at 7.

- The newsletter has the median number of unclickable pictures at 0.

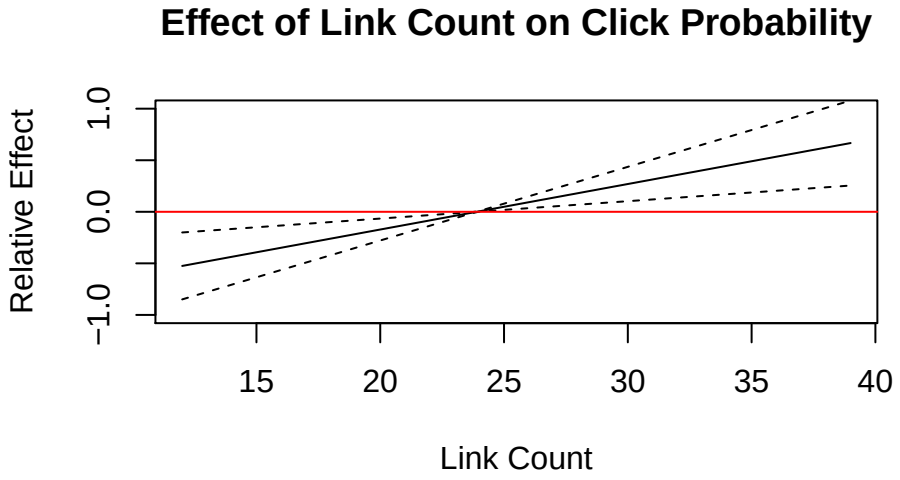


6.9 Number of Links Trend

The below barplot shows the proportion of subscribers that clicked on a link in the newsletter, given that the newsletter link count was within a specific interval.

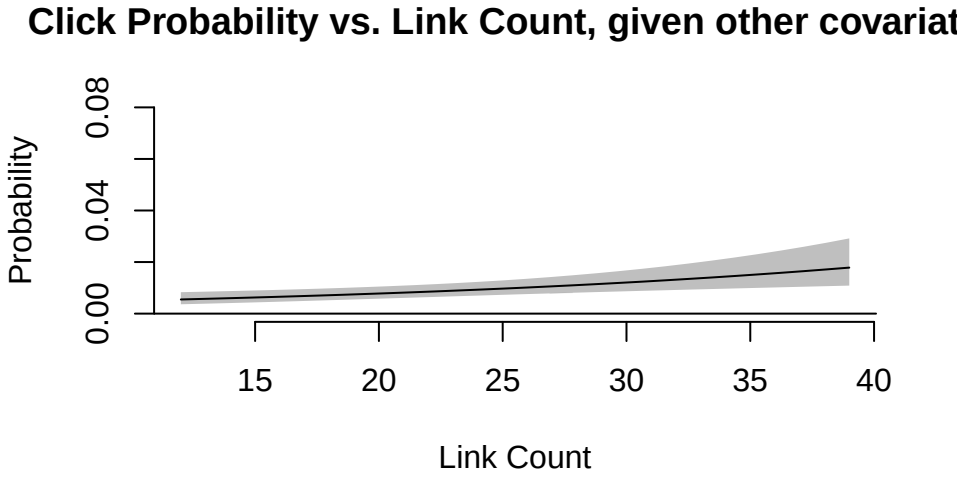


The following plot shows the relative effect of the link count on the click probability. More links is associated with a higher click probability.



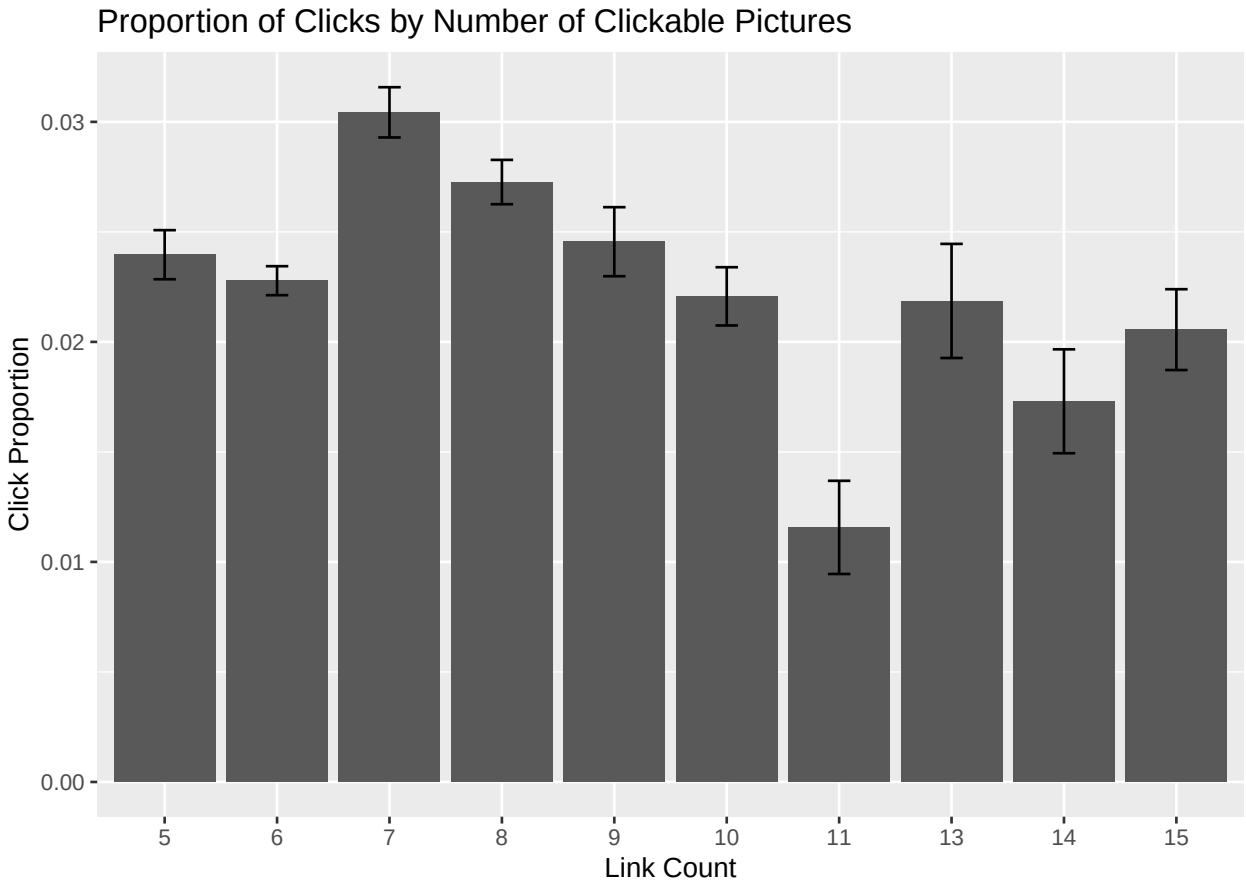
The above plot shows the partial effect of the link count alone, without considering other covariates. The following plot shows the actual estimated probabilities by link count under the following specific scenario:

- The newsletter was sent out on December 1, 2020.
- The newsletter was sent out at 10:30 am.
- The newsletter has the median subject length of 66 characters.
- The newsletter has the median number of words at 392 words.
- The newsletter has the median number of clickable pictures at 7.
- The newsletter has the median number of unclickable pictures at 0.

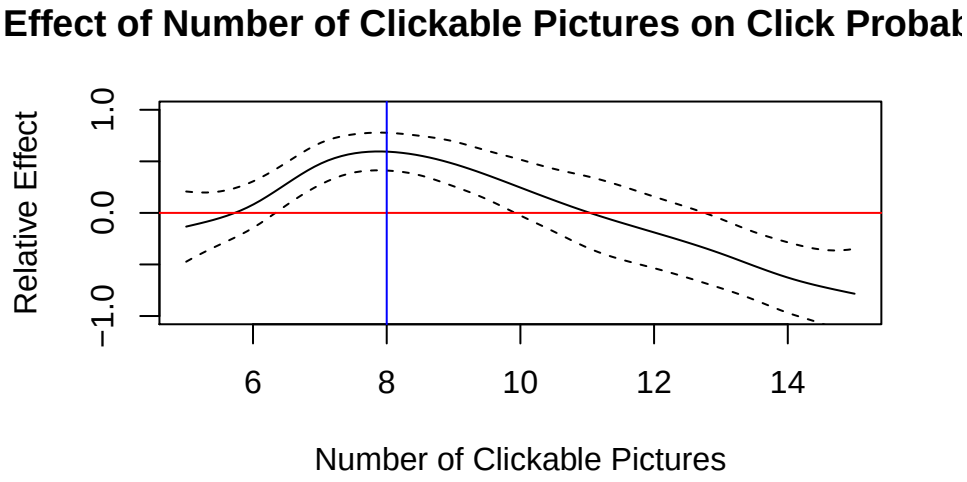


6.10 Number of Clickable Pictures Trend

The below barplot shows the proportion of subscribers that clicked on a link in the newsletter, given the number of clickable pictures in the newsletter.



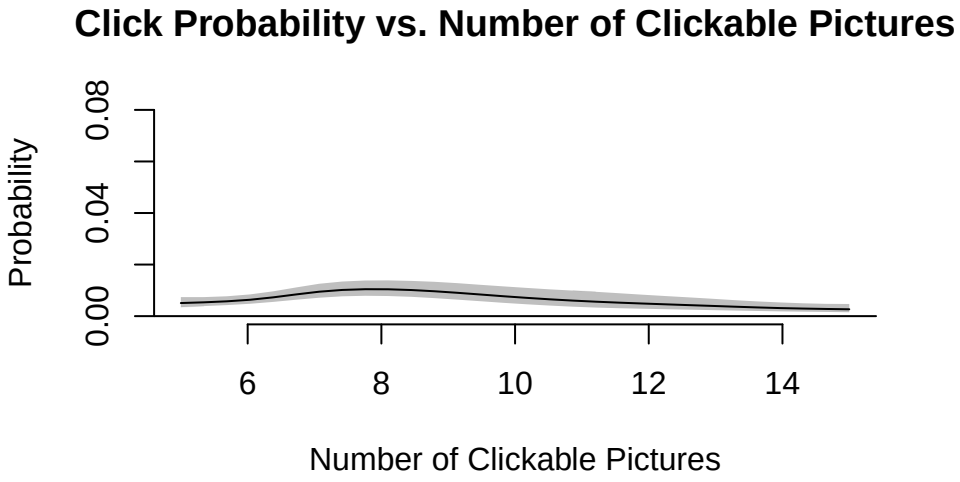
The following plot shows the relative effect of the number of clickable pictures on the click probability. The optimal number of clickable pictures appears to be 8.



The above plot shows the partial effect of the number of clickable pictures alone, without considering other covariates. The following plot shows the actual estimated probabilities by number of clickable pictures under the following specific scenario:

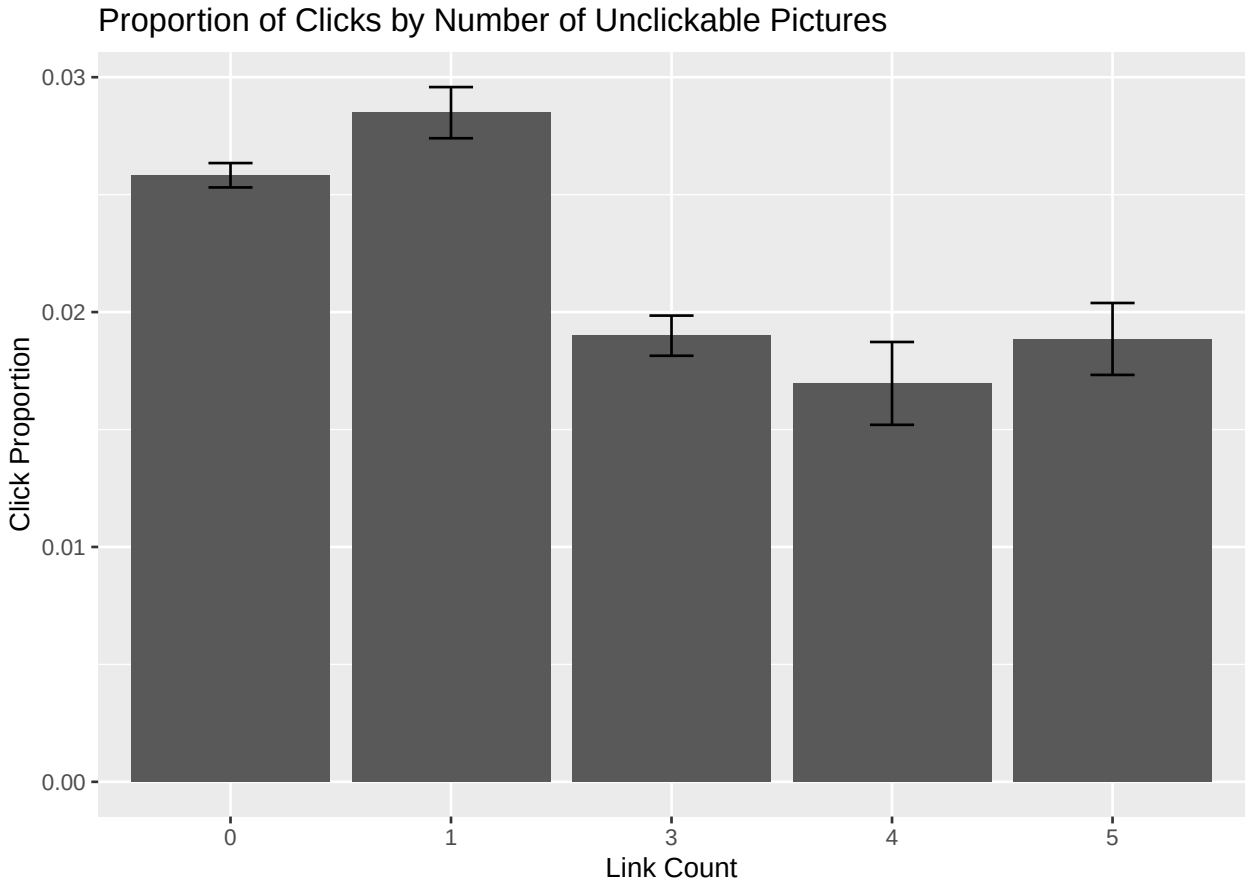
- The newsletter was sent out on December 1, 2020.
- The newsletter was sent out at 10:30 am.
- The newsletter has the median subject length of 66 characters.
- The newsletter has the median number of words at 392 words.

- The newsletter has the median number of links at 24 links.
- The newsletter has the median number of unclickable pictures at 0.



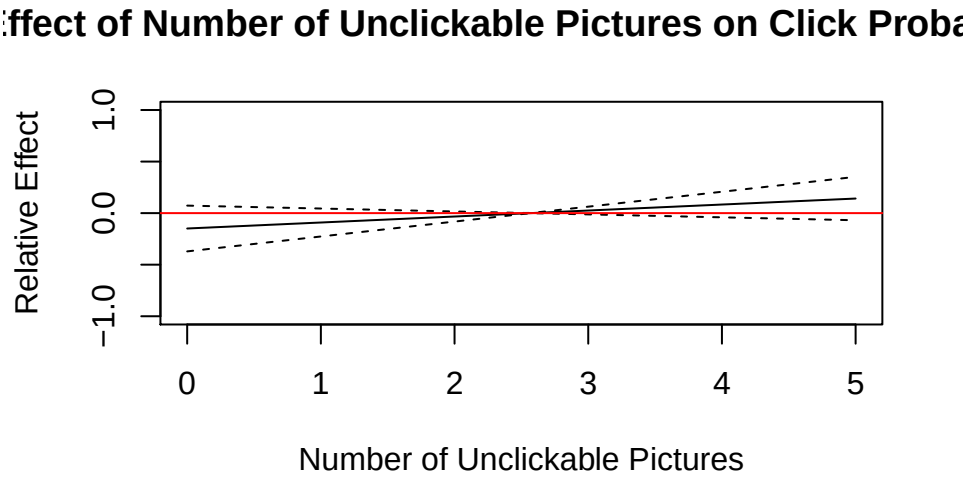
6.11 Number of Unclickable Pictures Trend

The below barplot shows the proportion of subscribers that clicked on a link in the newsletter, given the number of unclickable pictures in the newsletter.



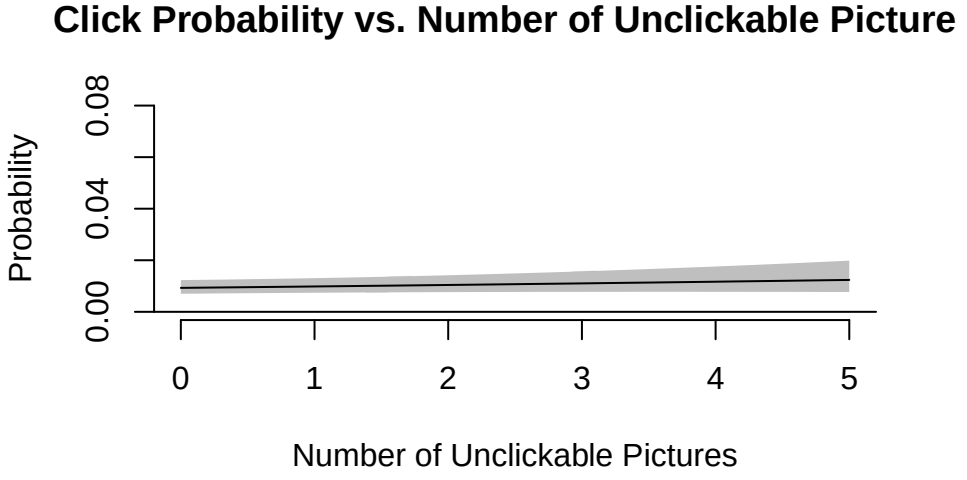
The following plot shows the relative effect of the number of unclickable pictures on the click probability.

The number of unclickable pictures does not have a significant effect on click probability



The above plot shows the partial effect of the number of unclickable pictures alone, without considering other covariates. The following plot shows the actual estimated probabilities by number of unclickable pictures under the following specific scenario:

- The newsletter was sent out on December 1, 2020.
- The newsletter was sent out at 10:30 am.
- The newsletter has the median subject length of 66 characters.
- The newsletter has the median number of words at 392 words.
- The newsletter has the median number of links at 24 links.
- The newsletter has the median number of clickable pictures at 7.



7 Link Characteristics that Promote Clicks: Executive Summary

7.1 Questions of Interest

- Which link characteristics (bolded, font size, font color, location within newsletter) lead to more clicks?
- Which topics mentioned in the links (e.g. animals, art, family, hunger) tend to attract clicks?

7.2 Statistical Analysis

- Bar plots to visually display click response based on link characteristics
- Statistical model to examine how factors interact and support the trends shown in the bar plots
- Qualitative analysis on the words associated with a link

7.3 Takeaways

- The location of the link in the newsletter affects how often it is clicked. Specifically, the further down the link is in the newsletter, the less likely it is to be clicked on. Therefore, we suggest placing the most important or time-sensitive links at the top of the newsletter.
- Links that are bolded get slightly more clicks than links that do not have bolded text.
- Links that are Mandarin Orange (146, 46, 33), Danube (65, 142, 190), or Denim (17, 85, 204) colored get more clicks than other colors.
- Contrary to our previous report on the trends in click probability, having a picture associated with a link does not statistically significantly increase the probability that a link will be clicked. However, links with an image still receive slightly more clicks than links that do not have an image.
- Opportunities with baby chicks and sharing one's skills are significantly popular.

8 Link Characteristics that Promote Clicks: Report

In this report, we investigate the characteristics of a links that make it more likely to be clicked on. We focus on newsletters from January 2019 to December 2020.

The rest of the report is organized as follows. First, we give a brief description of how the data was obtained and a synopsis of the assumptions we made to analyze the click data. Then, we introduce the features used in the model and analyze how click rates were affected by these features separately. Finally, we fit a statistical model to the data and interpret the results.

8.1 Data Description

The data comes from a few sources: the CSV and raw text files generated from iContact and the HTML source code from the links in each of the newsletters. From the CSV files, we determine the unique number of times a link was clicked on. We define a unique click to be a unique combination of subscriber ID, newsletter date, and link; in other words, if a subscriber clicked on the same link from the same newsletter, we do not count that click. We also identify the time of day the newsletter was sent and whether it was before or after the COVID-19 pandemic was declared (03/20/20) from the CSV files. The raw text files are used to get an approximation of how far down the newsletter the link is, e.g. a link that is about half-way down the newsletter would be estimated around 50%, and the text associated with a link. Finally, we obtain style characteristics and whether the link was an image or had an image associated with it from the HTML source code.

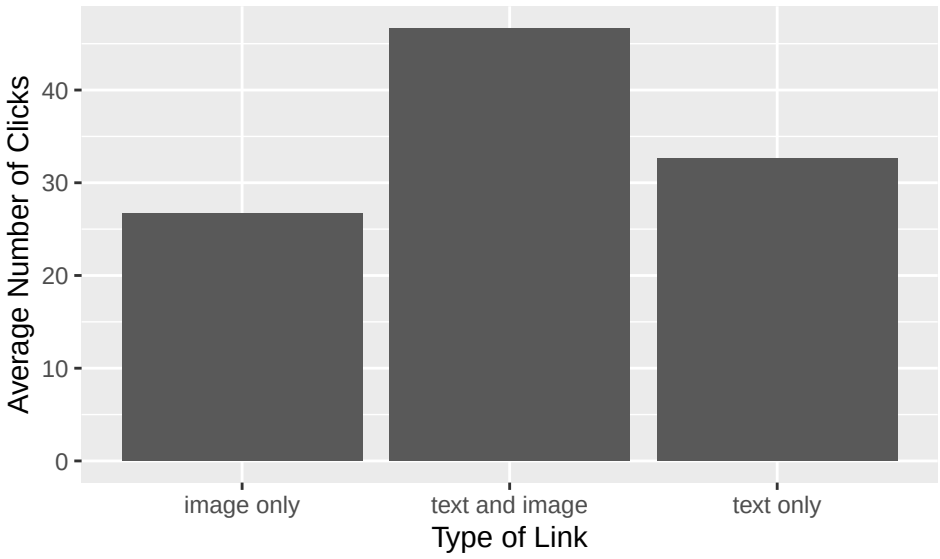
Additionally, we only know the click count for each link address, not the actual link, within a newsletter. Thus, if there are multiple links with the same address in a newsletter, we don't know how many clicks each of those links received. To alleviate this issue of duplicate links, we assume that the first text link with a given address received all the clicks associated with that address. We distinguish between unique links (those with addresses that appear only once) and duplicated links (those with addresses appearing multiple times) in our model.

Below is a summary of the features we created for text links:

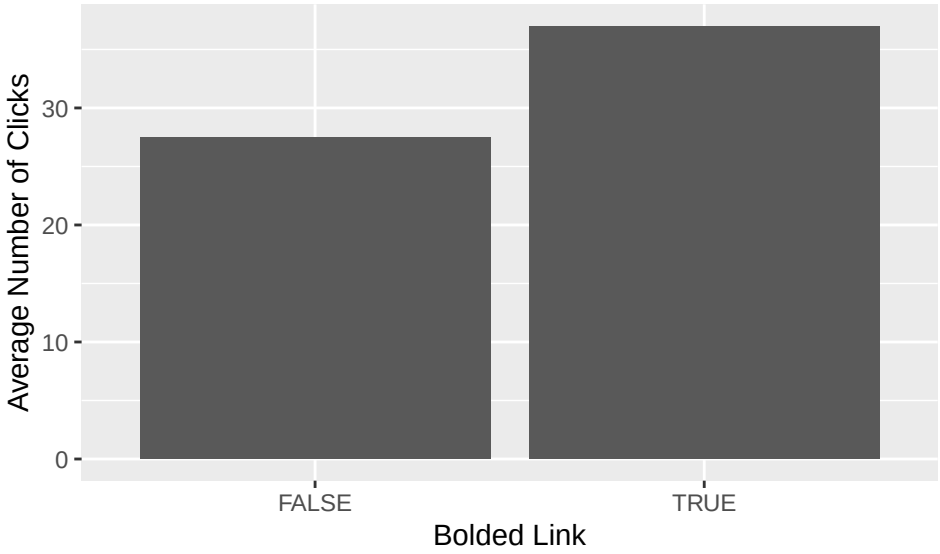
1. Bolded: whether the link text is bolded.
2. Font Size: ranges from 10-48 point.
3. Font Color: 26 possible colors.
4. Image Associated: indicator for whether there is an image within the newsletter with the same link address.
5. Hour: hour of when the newsletter was sent
6. COVID: indicator for whether the COVID-19 pandemic was underway
7. Location within document: cumulative percentage down the document a link is
8. Duplicate: indicator for whether the link was used more than once in a newsletter

8.2 Data Exploration

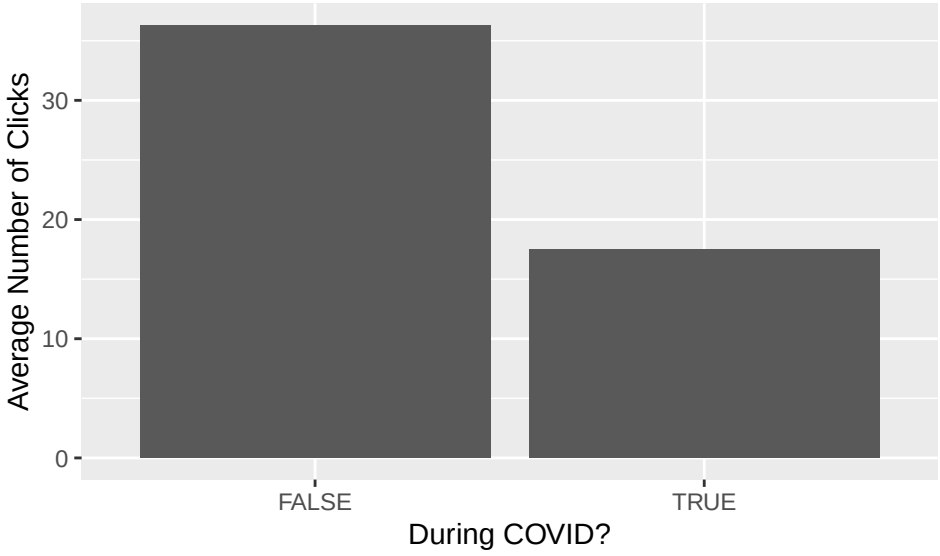
Before fitting any models to the data, we explore how the number of clicks a link received depended on the variables mentioned above. We define the average number of times a link was clicked as the number of times the link was uniquely clicked, defined above, divided by the number of newsletters the link appeared in. It is important to note that in doing this, we do not control for how many times a link was used within the same newsletter. For each of the categorical variables, we graph the category and the average number of times a link was clicked below.



In the bar plot above, the label 'image only' refers to links that only had a picture associated with it, 'text only' refers to links with only associated text, and 'text and image' refers to links with both an image and associated text. Based on the bar plot, it appears that a combination of text and pictures encourages people to click on a link.

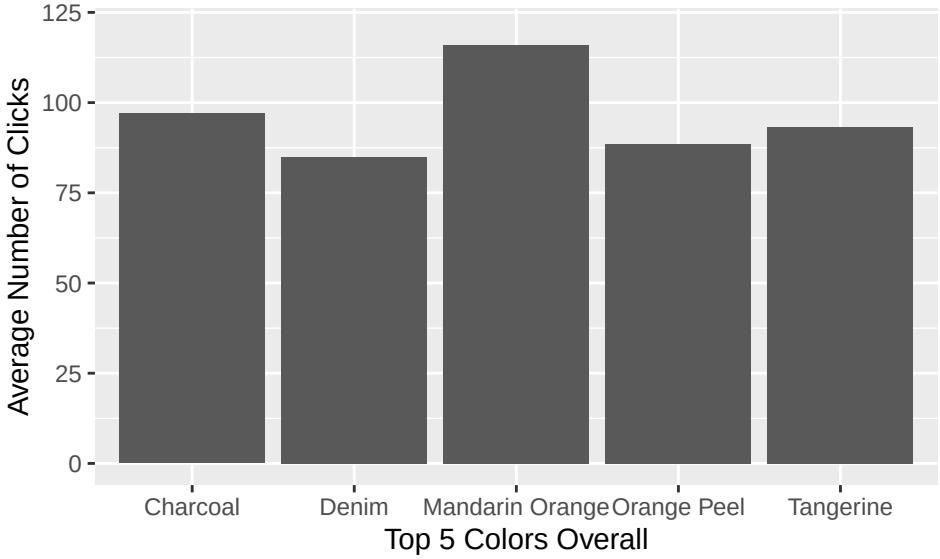


Based on the bar plot above, it appears the bolding the text associated with the link also increases the chance that someone clicks on it.

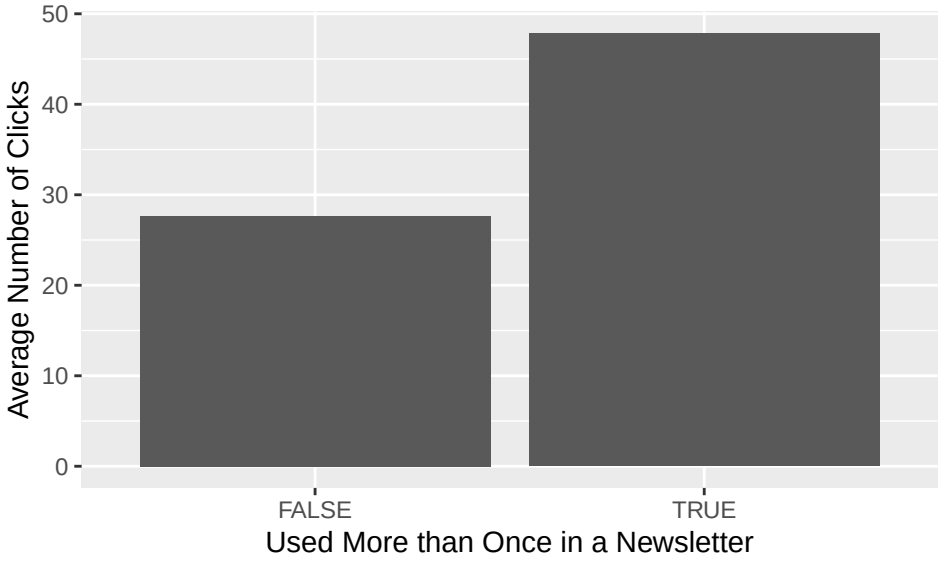


Based on the bar plot above, it seems COVID impacted how much subscribers choose to interact with the newsletters. This is not all that surprising given the challenges everyone was facing during the pandemic.

In the next two bar plots, we focus on the top five text color choices across all newsletters and the top five text color choices that appeared in more than one newsletter.



Any color of orange seems to grab people's attention! Mandarin Orange only appeared in the newsletter promoting the Remote Volunteer Project: DIY Family Essentials Kits opportunity so it is tempting to think the large number of clicks this color received may have more to do with the highly-relatable project. However, this project was advertised in four different newsletters using links colored as cinnabar and falu red (both are different tints of red) and these other newsletters had less than 85 clicks each. While there are more factors at play than just the link color, the fact that the newsletters advertising the same opportunity in red got fewer clicks suggests that a text color of orange is more impactful.



Finally, the bar plot above indicates that links that were used multiple times in a newsletter were clicked more often. This is somewhat surprising since interested individuals may click the first link they come to, but the plot above suggests more exposure to the opportunity encourages participating. However, the model below suggests this may not be the case.

8.3 Model Fitting

We attempted to fit a linear regression, a Poisson regression, and a Negative Binomial regression to the click data with no success. However, we found that if we divided the number of clicks by the number of subscribers each newsletter was sent to, a zero-inflated beta regression worked quite well. The beta regression allows us to model proportion data (data that's bounded between zero and one, non-inclusive); the "zero-inflated" in the name refers to extending the beta regression to include observations with a value of zero. The zero-inflated beta regression fits three parameters: mu, sigma, and nu. The mu variable corresponds to the mean of the click proportion (relative to the number of subscribers) and is modeled in a similar manner to simple linear regression.

The variables in our model are the following: doc_prop, bolded, color, font_size, hour, covid_ind, imag_assoc, and dup. "doc_prop" is the proportion down the document a link is; in other words, a link that is about halfway down a newsletter will be about 50%. "bolded" indicates whether a link was bolded. "color" is the color of the link as named by https://www.color-blindness.com/color-name-hue/.

Below we give a histogram of click proportion and the fitted model parameters for mu. From Table 1 below, we see that the link's location in the document, whether the link is bolded, and the color of the link make a statistically significant difference on whether the link is clicked or not. Additionally, we see the top five colors shown above are also statistically significant as well as Charcoal (67,67,67) and Falu Red (148,45,27). Interestingly, the indicator for whether the variable is duplicated or not is not significant in the model. This lack of significance may be because the location of the link in the document also somewhat captures this information.

Finally, the mu coefficients given in the table below are, unfortunately, uninterpretable in their raw form. Luckily, a transformation of these coefficients gives the odds ratio of each variable. For the variables that are statistically significant at or below the 0.001 level, we give the odds ratios in Table 2. The odds ratio is interpreted as follows: When the location of the link in the document increases by one percentage point the odds of it being clicked is 0.46 times the odds of it being clicked in the original position. Overall, an odds ratio greater than one indicates a positive association and an odds ratio less than one indicates a negative association; note, these agree with the signs of the coefficients in Table 1.

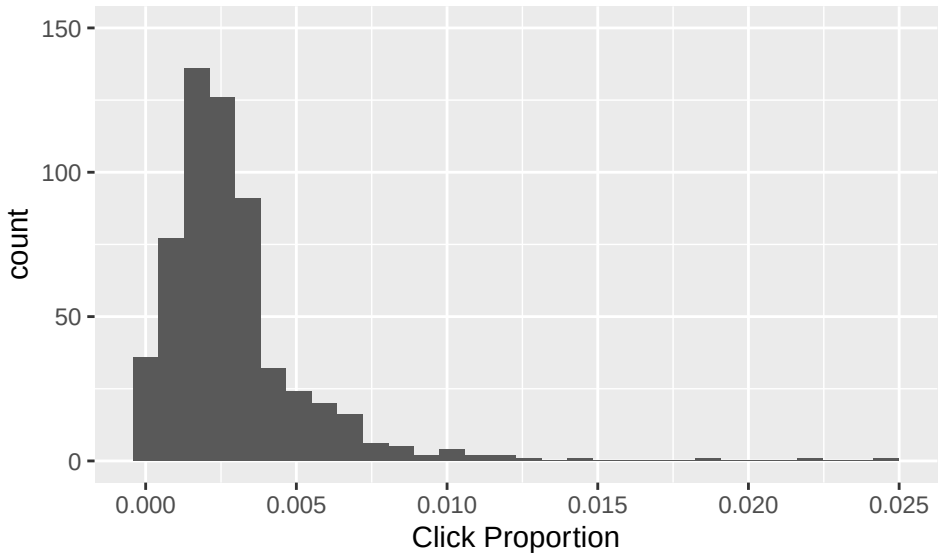

150
100
50
0
count
0.000
0.005
0.010
0.015
0.020
0.025
Click Proportion

Table 1: Mu Coefficients

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-5.96	0.26	-23.18	< 2e-16	***
doc_prop	-0.78	0.14	-5.56	0.00	***
boldedTRUE	0.22	0.06	3.50	0.00	***
color_nameBlack	0.61	0.36	1.71	0.09	.
color_nameBlack Pearl	-0.09	0.44	-0.21	0.84	
color_nameCharcoal	1.06	0.31	3.39	0.00	***
color_nameChocolate	0.47	0.24	1.93	0.05	.
color_nameCinnabar	0.07	0.33	0.23	0.82	
color_nameCitron	0.13	0.30	0.45	0.66	
color_nameDanube	1.62	0.34	4.72	0.00	***
color_nameDenim	1.49	0.31	4.84	0.00	***
color_nameDim Gray	-0.23	0.73	-0.32	0.75	
color_nameEastern Blue	0.28	0.25	1.09	0.28	
color_nameEclipse	0.37	0.24	1.58	0.12	
color_nameFalu Red	0.64	0.24	2.70	0.01	**
color_nameGamboge	0.15	0.53	0.29	0.77	
color_nameGrey	0.18	0.24	0.77	0.44	
color_nameMandarin Orange	1.35	0.38	3.52	0.00	***
color_nameMariner	0.26	0.59	0.43	0.67	
color_nameNero	0.18	0.68	0.27	0.79	
color_nameOrange Peel	1.04	0.34	3.08	0.00	**
color_nameSlate Blue	0.45	0.61	0.75	0.46	
color_nameTangerine	0.94	0.28	3.42	0.00	***
color_nameTeal	0.44	0.24	1.82	0.07	.
color_nameTenne	0.85	0.44	1.92	0.06	.
color_nameTyrian Purple	0.28	0.55	0.51	0.61	
color_nameWhite	0.42	0.24	1.72	0.09	.
font_size	-0.01	0.01	-1.03	0.31	
hour	0.01	0.01	1.29	0.20	
covid_indTRUE	-0.70	0.08	-9.17	< 2e-16	***
image_assocTRUE	0.03	0.10	0.32	0.75	
dupTRUE	0.12	0.09	1.30	0.19	

Table 2: Odds Ratio

	Estimate	Odds Ratio
(Intercept)	-5.96	0.003
doc_prop	-0.78	0.460
boldedTRUE	0.22	1.240
color_nameCharcoal	1.06	2.884
color_nameDanube	1.62	5.061
color_nameDenim	1.49	4.445
color_nameFalu Red	0.64	1.896
color_nameMandarin Orange	1.35	3.845
color_nameOrange Peel	1.04	2.817
color_nameTangerine	0.94	2.571
covid_indTRUE	-0.70	0.495

8.4 Qualitative Text Analysis

Finally, we explored what words encouraged subscribers to click on a link by creating word clouds. The word clouds are composed of the capitalized words that were contained in each link. (The requirement for capitalization was to eliminate filler words.) the size of the words corresponds to the proportion of unique clicks relative to the number of total clicks a newsletter obtained. Note, this is slightly different than the proportion of clicks defined above for the zero-inflated beta model.

The first word cloud below is for any links that were not social media for Activate Good.

The second word cloud below is for links that were for opportunities as defined by the link containing "opportunity" in the address; these links correspond to volunteer opportunities for subscribers.

As we can see, opportunities with baby chicks and sharing one's skills are significantly popular compared to other opportunities!

9 Appendix (Color RGB Values and Opportunity Link Click Frequency Table)

Here we provide the RGB values for all of the colors that were present in the news letter links. The names were assigned according to https://www.color-blindness.com/color-name-hue/.

Color Names
Bahia (179,183,27)
Black (0,0,0)
Black (10,10,10)
Black Pearl (29,33,41)
Charcoal (67,67,67)
Chocolate (228,104,16)
Chocolate (233,93,20)
Cinnabar (231,93,38)
Citron (152,154,38)
Danube (85,142,190)
Denim (17,85,204)
Dim Gray (97,97,97)
Eastern Blue (0,136,168)
Eclipse (55,55,55)
Eclipse (57,57,57)
Falu Red (148,45,27)
Gamboge (228,134,9)
Grey (127,127,127)
Mandarin Orange (146,46,33)
Mariner (56,88,152)
Mortar (85,85,85)
Mortar (89,89,89)
Nero (34,34,34)
Orange Peel (255,150,0)
Orange Peel (255,151,9)
Slate Blue (102,94,208)
Tangerine (238,135,2)
Tangerine (242,124,0)
Tangerine (242,136,0)
Tangerine (248,118,0)
Teal (0,109,131)
Tenne (206,86,0)
Tyrian Purple (13,0,0)
White (255,255,255)